THE PRINCIPLES OF EXERCISE THERAPY

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BY

M. DENA GARDINER, F.C.S.P.
Diploma of Bedford Physical Training College
Teacher of the Chartered Society of
Physiotherapy (T.M.M.G. and T.E.T.)
Deputy Principal of the London Hospital School of Physiotherapy

WITH A CHAPTER ON
PROPRIOCEPTIVE FACILITATION
BY
MONICA MARTIN JONES, M.C.S.P.

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FOREWORD

by

WILLIAM TEGNER, F.R.C.P.
Physician in Charge, Department of Physical Medicine,
The London Hospital

PHYSIOTHERAPY is no static art. Methods of treatment constantly change and many that were once prominent and popular have lost popularity. In this way many treatments involving the use of electrical currents have gone out of fashion, massage itself is looked at with a cold scientific eye and does not emerge unscathed from the appraisal, and passive treatments of inert patients making no effort to help themselves are regarded as possibly prolonging rather than cutting short invalidism. Yet in spite of all this more patients are referred for physiotherapy than ever before. The gospel of activity has been widely preached and the prescription of activity and movement has taken the place of the passive treatments so widely advocated before the second world war. There seems little doubt that this phase of activity is a notable advance and that patients are reaping the benefit of it.

No one could be better qualified than Miss Dena Gardiner to write on the Principles of Exercise Therapy, for she holds both a Diploma in Physical Education and the double teacher's qualification of the Chartered Society of Physiotherapy. She has a deservedly high reputation as a teacher and demonstrator and, as this book will show, she has succeeded admirably in setting out the principles that govern the therapeutic value of activity.

PREFACE

THIS book has been written for all those who are interested in the use of exercise to promote physical rehabilitation. It is, however, primarily designed to provide students training in physiotherapy with a simple theoretical background for the practical instruction they receive in the performance and use of movement and exercises for therapeutic purposes.

I have attempted to collect and integrate the various techniques now in common use and to arrange them according to the purpose for which they are designed. To do this I have drawn freely upon the ideas and experience of others as well as my own but, except in the case of forced passive movements which have only rarely been ordered by any doctor for whom I have worked, I have included only those procedures which I have tried out and found to be of value in the treatment of patients at one time or another.

New and widely varying techniques are constantly being developed and no one of these can claim to be suitable for all patients or all physiotherapists. A sound knowledge of basic principles, an open mind and a spirit of enquiry are essential to progress and the discovery of the methods most suitable to achieve results.

> I keep six honest serving men,
> (They taught me all I knew)
> Their names are What and Why and When
> And How and Where and Who.
>
> KIPLING'S *The Elephant Child*

Although there are a considerable number of male physiotherapists, to facilitate description throughout the text I have referred to the physiotherapist as 'her' and to the patient as 'him'.

I would like to express my gratitude to all who have helped me in the preparation of this book. In particular my thanks are due to Dr. W. S. Tegner, B.M., B.Ch., F.R.C.P., who not only read my manuscript and gave me valuable advice but has kindly written the foreword.

I am deeply indebted also to Dr. L. A. W. Kemp, B.Sc., F.Inst.P., physicist to the London Hospital, for his interest and patience in helping me to prepare the chapter on Mechanical Principles and to Dr. M. Partington, M.B., of the Physiology Department, for many helpful suggestions.

Miss Y. Moyse, M.A., who was at the time Public Relations Officer

for the Ling Physical Education Association, encouraged me to undertake the task of writing this book, and she has at all times advised and helped me in the preparation of the manuscript. I would like to take this opportunity of expressing my appreciation and thanks for the time and energy she has given to help me.

My colleagues in the Chartered Society of Physiotherapy have always been ready to discuss controversial matters and to give me advice whenever I asked for it, and I am most grateful to them and to Miss Chatwin, M.C.S.P., who lent me a typewriter for as long as I needed it.

M. D. G.

June 1913

PREFACE TO THE SECOND EDITION

THE techniques of Exercise Therapy are constantly being reviewed and modified, therefore I have thought it advisable to make several alterations and additions in an attempt to keep this book in line with modern thought and practice.

I am very glad to be able to include a chapter on Proprioceptive Facilitation written by Miss Monica Martin Jones as an introduction to this method of neuromuscular re-education. I am most grateful to her for making this contribution and for completing it in spite of the fact that she left England at very short notice to help in the rehabilitation of poliomyelitis victims in Argentina. I am well aware that at present there are only very few physiotherapists in this country who have had the opportunity to learn enough of these techniques to practise them even in their most simple form, but I am convinced that the physiological principles on which they are based are of such importance that this method of applying them should be more widely known and understood. This chapter, in common with the rest of the book, is intended to stimulate interest and to provide a simple theoretical background as an adjunct to practical instruction whenever and wherever this is available.

It is of great importance that methods new to this country should be examined and tried out, as each one contributes, in a greater or lesser degree, something of value to the physiotherapist for use in the treatment of patients.

M. D. G.

July 1916

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PART I

I

MECHANICAL PRINCIPLES

THE mechanical principles utilised in Exercise Therapy are defined here to ensure that they are understood and applied correctly.

FORCE

Force is that which alters the state of rest of a body or its uniform motion in a straight line.

Composition of Forces

The application of a force to a body is specified by—

(*i*) the direction of the force; this may be represented by the direction of an arrow,

(*ii*) the magnitude of the force; this may be represented by the length of the arrow.

The tail of the arrow drawn to represent a force can be taken as the point of application of that force.

FIG. 1

A single force applied to a body, which is free to move, causes movement in the direction of the force. (Fig. 1).

a. Two forces acting in the same direction and at a common point

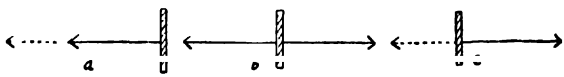


FIG. 2

are equivalent to a single force acting in that direction, whose magnitude is equal to the sum of the magnitudes of the individual forces.

b. Two equal forces acting at a common point, and in opposite directions, will result in a state of equilibrium.

c. Two unequal forces acting at a common point and in opposite directions will result in movement in the direction of the greater force, the magnitude of the force producing this movement being equal to the difference between the magnitudes of the two unequal forces which oppose each other.

Sometimes it is inconvenient to apply force in a particular direction and in these circumstances two forces acting at an angle to each other may be compounded to produce the desired effect.

If two forces represented by the lines AB and AC act at A, then the

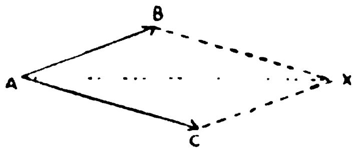


FIG. 3. The Parallelogram of Forces

diagonal AX of the parallelogram ABXC represents the force to which they are equivalent. One example of this occurs when the Deltoid Muscle contracts during shoulder abduction, the action of the anterior and posterior fibres of the muscles being compounded to work with the middle fibres and so vastly increasing their power.

The principle of compounding forces is also employed in some arrangements for balanced traction.

MECHANICS OF POSITION

GRAVITY

Gravity is the force by which all bodies are attracted to the earth. Newton concluded from experiments and observations that a force of attraction existed between all material objects, and that the magnitude of this attraction was directly proportional to the mass of each body and inversely proportional to the square of the distance between them. The gravitational attraction of the earth for every other body is directed towards the earth's centre.

The force of gravity acts continuously upon the human body, and if unopposed the latter will fall to the ground. The effects of gravity can be counterbalanced when a force equal and opposite to it is employed, such as the support of a plinth, the buoyancy of water, or a static muscular contraction. If, however, gravity is opposed by a force which is greater, movement will occur in the direction of that force.

For example:—

a. From the standing position the heels can be raised from the ground by the contraction of the calf muscles, working in opposition to the resistance of gravity, provided the force of their contraction exceeds the force of gravity.

b. The heels will remain raised as long as the force of the static contraction of the muscles is equal to that of gravity.

c. The heels will be lowered to the ground by the action of gravity if the muscles relax.

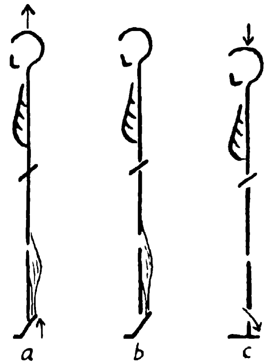


FIG. 4

Movement of joints may occur as the result of gravity or of muscular action, and each may control the effect of the other. In the erect position balance is maintained by the reciprocal contraction of many muscles, called the anti-gravity muscles, while true relaxation can only occur under conditions in which the muscles are no longer required to work against the effects of gravity, as the latter are cancelled out by adequate support.

THE CENTRE OF GRAVITY

The centre of gravity of a rigid body is the point in it through which the earth's attraction effectively acts whatever the position of the body, i.e. the point through which the line of action of the weight acts. A rigid body will balance when it is supported only at its centre of gravity.

a. A uniform rod will balance at a point exactly half-way along its length.

b. The centre of gravity of an irregular piece of cardboard can be discovered by suspending it consecutively from at least two points at its margin, and marking on it the line taken by a plumb line when the

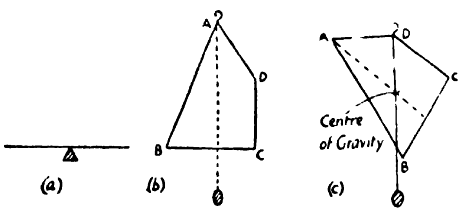


FIG. 5

latter is attached at the point of suspension in each position. The point of intersection of the two lines will be the centre of gravity (Fig. 5*c*), which need not necessarily lie within the body, as in the case of a ring or a boomerang.

The centre of gravity of the human body in the anatomical position is reputed to be in the vicinity of the body of the second sacral vertebra. Its position must vary, however, according to the anatomical structure of the individual, being higher in men and children than in the average woman, because of the greater amount of weight they carry in the upper half of the body. Direct support at the centre of gravity of the human body is obviously impossible and its exact position is merely of interest in assessing the distance between it and the point of support.

The location of the centre of gravity will vary with each of the many and varied postures the body assumes.

Line of Gravity

The line of gravity is a vertical line through the centre of gravity.

When the human body is in the fundamental standing position the line of gravity through the body of the second sacral vertebra passes through the vertex and a point between the feet, level with the transverse tarsal joints. The relationship of body structures to this line is subject to considerable variation in accordance with individual differences in posture and anatomical structure. It is estimated that on an average when posture is good the line passes through the mid-cervical and mid-lumbar vertebrae and in front of the thoracic vertebrae. The external ear and the point of the shoulder are in the same frontal plane and lie lateral to the line, and the central axis of the knee joint and the ankle joints are postero-lateral.

Base

The base, as applied to a rigid body, is the area by which it is supported. In the case of a cube the face on which it rests is the base,

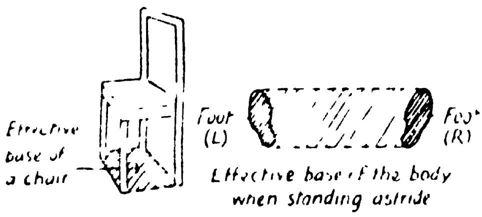


Fig. 6

whereas the effective base of a chair may be considered as the area bounded by the lines joining the legs.

In the lying position the posterior aspect of the whole body forms the base, and in stride standing it is an area as wide as the feet and as long as the distance between their outer borders.

EQUILIBRIUM

Equilibrium results when the forces acting upon a body are perfectly balanced and the body remains at rest.

Stable Equilibrium. If the forces acting upon a body at rest tend to restore it to its original position after it has been displaced, the body is said to be in stable equilibrium. The condition of equilibrium is most stable when the centre of gravity is as low as possible and the line of gravity falls near the centre of an extensive base. It becomes progressively less stable as the centre of gravity is raised and the line of gravity falls nearer to the margin of the base.

Unstable Equilibrium. If a body is given an initial displacement and the forces acting upon it increase this initial displacement, however small the latter may be, the body is said to be in unstable equilibrium. A centre of gravity which is as high as possible and a small base result in *relatively* unstable equilibrium, because even very small displacements cause the line of gravity to fall outside the base, and the body will fall to the ground.

Neutral Equilibrium. If, in spite of displacement of a body, the height and position of its centre of gravity remain the same in relation to the base, the body is said to be in neutral equilibrium, as, for example, when a ball moves on a plane surface.

The stability of the human body is greatest in the lying position. It becomes progressively less stable as the centre of gravity is raised and the base is reduced, as in the sitting and standing positions.

FIXATION

Fixation or stabilisation of bones or joints is achieved by a balance of the opposing forces acting upon them. These forces may be provided by muscular contraction, manual pressure or by mechanical means such as splints.

Contraction of a muscle group is most effective in the performance of movement when the bone or bones of origin are stabilised so that contraction results in movement of the bone or bones of insertion (or vice versa when the group works with reversed origin and insertion). This stabilisation (or fixation) is normally achieved by other muscle groups working to control movement in neighbouring joints. If, however, the power or co-ordination of these 'fixator' muscles is inadequate, an additional force or forces may be applied to compensate for their deficiency.

In giving forced passive movements fixation of the bone proximal to the joint to be manipulated is essential to ensure localisation of the movement.

Fractures, joint injuries and disease necessitating long-term immobility of joints usually require fixation by mechanical means such as splintage, balanced traction or operative measures, e.g. bone grafting or plating.

MECHANICS OF MOVEMENT

Axes and Planes

An axis is a line *about* which movement takes place and a plane is the surface which lies at right angles to it and *in* which the movement takes place. The terms are used to facilitate the description of movement or direction, and as far as axes and planes of joint movement are concerned, they are described with the body in the anatomical position.

a. A sagittal axis lies parallel to the sagittal suture of the skull, i.e. in an antero-posterior direction, as an arrow might have pierced a yeoman in attack or in flight. Movement about this axis is in a *frontal plane.*

b. A frontal, or transverse, axis lies parallel to the transverse suture of the skull. It is also horizontal and at right angles to the sagittal axis. Movement about a frontal axis is *in a sagittal plane.*

c. A vertical axis lies parallel to the line of gravity and movement about it is in *a horizontal plane.*

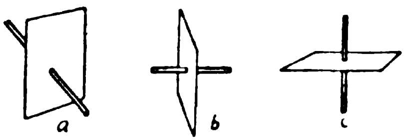


Fig. 7

The hands of a watch moving about the central pin and over the watch face, or a pencil thrust through a sheet of paper and turned to represent the three axes, are convenient examples to demonstrate axes and planes.

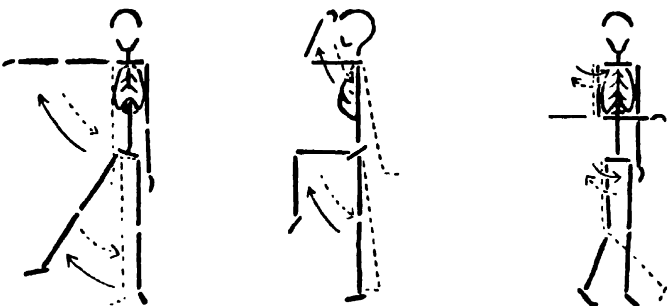
Movements of the body occur at joints, therefore axes pass through joints and the part moved is in the plane which lies at right angles to the axis of the movement.

Abduction and adduction (except of the thumb) and side flexion movements take place about a sagittal axis and in a frontal plane, flexion and extension (except of the thumb) about a frontal axis and in a sagittal plane, and rotation occurs about a vertical axis and in a horizontal plane.

The Plane of Movement and Gravity

Movement in the Horizontal Plane. Movement in the horizontal plane is in no way affected by gravity and is therefore stated to be 'gravity free'. Weak muscles which are unable to produce movement against gravity can often succeed in doing so when the part moved is supported horizontally.

Movement in the Inclined Plane. Movement in this case can be up the incline or downwards. When muscles work to produce movement up the incline, the resistance offered to them by the force of gravity is modified and reduced by the reaction of the plane. The latter is greatest when the incline is nearly horizontal, therefore the resistance to the muscles is least when the incline is nearly horizontal



a b c

FIG. 8

(*a*) Movement about Sagittal Axis and in Frontal Plane

(*b*) Movement about a Frontal Axis and in a Sagittal Plane

(*c*) Movement about a Vertical Axis and in a Horizontal Plane

and increases as it approaches the vertical. Movement downwards is produced by the force of gravity, the magnitude of its force increasing as the inclination approaches the vertical and the reaction of the plane decreases.

Movement in the Vertical Plane. Upward movement is produced by a force such as that of muscular contraction which exceeds the force of gravity. Downward movement is produced by the force of gravity and occurs at a specific speed which can be modified and controlled by muscular action.

SPEED

Speed is merely the rate at which a body moves, and takes no account of the direction, i.e. a car has a speed of forty miles an hour. Speed is uniform if the car travels the same distance during every second that it moves, but if it slows down at a turning and then increases speed along a straight road to make up for lost time, its speed is variable, but the average speed for a given time can be calculated.

Speed of Relaxed Passive Movements

The speed at which a passive movement is performed must be slow and uniform so that relaxation can be maintained.

Speed of Active Exercises

Natural Speed. There is a natural speed for every exercise which varies to some extent for each individual and, in general, this is the speed at which exercises should be done. The effect of many exercises can be modified, however, by an alteration in the speed of their performance.

Reduced Speed. Exercises done more slowly require greater muscular effort and more control. Decrease in the speed of repetitive movements ensures time for full-range movement.

Increased Speed. Rapid movement also requires strong muscular effort but momentum is gained and this may help to increase the range of joint movement provided the direction is not reversed before the free limit is reached. Exercises performed rapidly are stimulating but frequently lead to inaccurate or 'trick movements' and full-range movement is rarely achieved.

VELOCITY

The notion of velocity incorporates not only the rate of motion but also the *direction*, e.g. an aeroplane travels at 500 miles an hour *in an easterly direction.* A change in either speed or direction is said to alter the velocity.

ACCELERATION

Acceleration is the rate of change of velocity. A positive acceleration causes an increase and a deceleration, or retardation, a decrease in velocity.

Movement under Gravity. Galileo dropped heavy bodies from the leaning tower of Pisa and established the fact that all bodies, irrespective of their weight, are subject to the same uniform acceleration as they fall freely under gravity.

MOMENTUM

The momentum of a body is the quantity of motion it possesses, and it is represented by the product of mass and velocity. The force responsible for the momentum will generate movement slowly in a relatively heavy body and more rapidly in a lighter body.

INERTIA

Inertia is the resistance of a body to any change in its state of rest or motion. A body at rest tends to remain at rest indefinitely, while a moving body tends to continue moving at a constant speed and in a straight line unless acted upon by a force.

A railway truck in a goods yard requires considerable force to start it moving, but once it gets going it continues until another force, such as collision with the buffers of another truck, impedes it. If there was a man standing in the first truck he would be thrown forward at the moment of collision, as his body would continue moving, owing to inertia.

FIG. 9

Once the inertia of the body is overcome and movement is initiated, it is more economical to continue moving, as in a well co-ordinated swimming stroke or running action, to avoid the additional expenditure of force which would be required to overcome the inertia on stopping, starting or altering speed. Weak muscles may be unable to exert sufficient force to overcome inertia, yet may be able to produce movement or control with assistance at the right moment.

FRICTION

Friction is the force which opposes motion when one surface slides upon another. It may be sufficient to prevent movement altogether, e.g. as in the case of rough surfaces or substances, such as rubber, when they are in contact with one another. The frictional resistance obtaining during movement (dynamic friction) is slightly less than the so-called limiting friction, i.e. the friction obtaining just as sliding is about to set in. Dynamic friction may be further reduced during movements of a limb, while the latter remains supported by a plane surface, by the use of a polished surface such as a table or plinth on which the limb will slide. The use of talcum powder or oil on the supporting surface will further reduce friction and make the movement easier, whereas suspension of the part to be moved virtually eliminates all frictional resistance.

SIMPLE MACHINES, PENDULUMS AND ELASTICITY

A machine is a contrivance which enables an applied force to overcome a given resistance. The use of a machine usually makes it possible for the magnitude of the applied force to be less than that of the resistance which it overcomes, or when this is not so, it enables the force to be applied more conveniently.

Levers and pulleys are examples of simple machines in common use in everyday life and their principles are also utilised for the production of movement in the human body.

Levers

A lever is a rigid bar which is capable of movement about a fixed point called a *fulcrum* (F). Work is done when a force or *effort* (E), applied at one point on the lever, acts upon another force or *weight* (W), acting at a second point on the lever. The perpendicular distance from the fulcrum to the effort (E) may be called the *effort's arm* and that from the fulcrum to the weight (W) as the *weight's arm.*

In the body a lever is represented by a bone, which is capable of movement about a fulcrum formed at the articulating surfaces of a joint; the effort which works the lever is supplied by the force of muscular contraction, applied at the point of insertion to the bone, while the weight may be either at the centre of gravity of the part moved, or of the object to be lifted.

There are three Orders or Classes of levers, each of which is characterised by the relative positions of the fulcrum, effort and weight.

1st Order. The fulcrum is between the effort and the weight; it may be situated centrally, or towards either the effort or the weight,

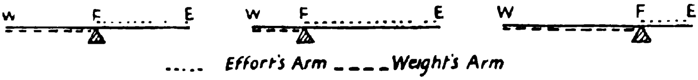


FIG. 10. 1st Order of Levers.

consequently the effort's and the weight's arms may be equal, or one may exceed the other in length.

2nd Order. The weight is between the fulcrum and the effort, and the effort's arm must therefore always exceed the weight's arm.

FIG. 11. 2nd Order of Levers

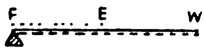


FIG. 12. 3rd Order of Levers

3rd Order. The effort is between the fulcrum and the weight, and the weight's arm must therefore exceed the effort's arm.

Mechanical Advantage. The efficacy of a force in relation to a lever is dependent upon two factors, i.e. the force exerted (W) or (E), and its perpendicular distance from the fulcrum (weight's arm or effort's arm). The product of these two factors is known as the Moment of Force (or torque). When the weight's and effort's arms are of equal length an effort of a magnitude equal to that of the weight will be required to lift it. No advantage is gained but the machine is useful for measuring weights as, for example, in the common balance.

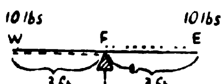


FIG. 13. State of Equilibrium

If, however, the length of the effort's arm exceeds that of the weight's arm, less effort will be required to achieve a similar result and an advantage will be gained by the use of the lever. This is known as a Mechanical Advantage, and it is obtained in levers of the 1st Order when the fulcrum is nearer to the weight than to the effort, and in all levers of the 2nd Order. It is never obtained in levers of the 3rd Order.

Mechanical Advantage is the ratio of the weight to the effort, expressed thus:—

$$\text{M.A.} = \frac{\text{W}}{\text{E}}$$

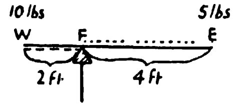


FIG. 14. Mechanical Advantage

Moment of Force 10 × 2 = 20 ft. lbs. 4 × 5 = 20 ft. lbs.

$$\text{M.A.} = \frac{10}{5} = 2$$

Conversely, in cases in which the weight's arm exceeds the effort's arm, a condition of Mechanical Disadvantage occurs, as in levers of the 1st Order, when the fulcrum is nearer to the effort than to the weight and in all levers of the 3rd Order.

Levers of the Body

Examples of all three Orders of levers are found in the human body, but those of the 3rd Order are most numerous.

1st Order. The feature of this Order is stability, and a state of equilibrium can be achieved either with or without mechanical advantage. One example of this type of lever is demonstrated during nodding movements of the head; the skull represents the lever, the

FIG. 15

atlanto-occipital joints the fulcrum, the weight is situated anteriorly in the face, and the effort is supplied by the contraction of the posterior Neck Muscles, applied at their attachment to the occipital bone. Another example is tilting movements of the pelvis on the femoral heads.

2nd Order. This is the lever of power as there must always be a mechanical advantage. An example in the lower limb is demonstrated when the heels are raised to stand on the toes. The tarsal and metatarsal bones are stabilised by muscular action to form the lever, the fulcrum is at the metatarsophalangeal joint, and the weight of the body is

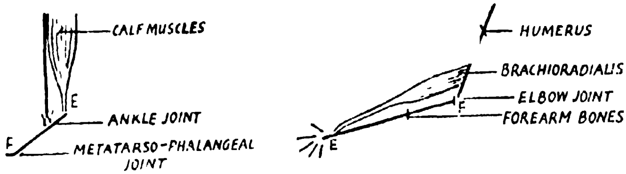


FIG. 16

transmitted through the ankle joint to the talus. The effort is applied at the insertion of the tendo-calcaneum by the contraction of the Calf Muscles. In the arm, the action of Brachioradialis Muscle in flexing the elbow joint can be taken as another example of a type of lever which is relatively uncommon in the body.

3rd Order. In the human body there are more examples of the 3rd Order of levers than of any other type. This type of lever, in which there is always a mechanical disadvantage, is the lever of velocity, the loss of mechanical advantage being outweighed by the advantage gained by speed and range of movement. Both in the days of primitive man and in modern times, speed and range of movement have often proved to be a greater asset than power.

When the lever is the forearm, the fulcrum is the elbow joint, and when the effort is supplied by the contraction of the Brachialis Muscle applied at its insertion, and the weight is some object held in the hand,

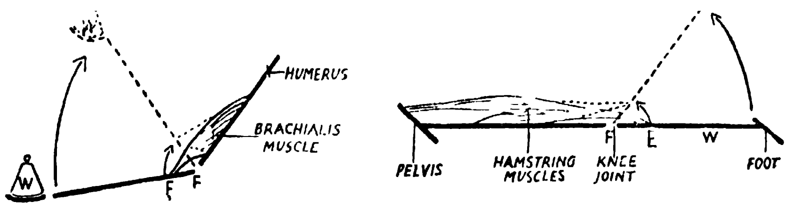


FIG. 17

it can be seen that a small amount of muscular contraction will be translated into a much more extensive and rapid movement at the hand. The action of the Hamstring Muscles in flexing the knee is another simple example.

Levers at Home and at Work

Many examples of lever are found in the use of common tools and household utensils. A seesaw, a tack lifter, and a crowbar used across a log as fulcrum are all levers of the 1st Order, while a pair of scissors are twin levers of this type with a common fulcrum. The use of a laden wheelbarrow is typical of the 2nd Order, and it is worthy of note that every door is made easier to open owing to the fact that the handle is placed as far from the hinges as possible. The 3rd Order is demonstrated by a man lifting a long ladder with its foot against a wall, or in the use of sugar-tongs or forceps, which are double levers of this Order.

Levers in Physiotherapy

A knowledge of the lever principles is necessary for the understanding of an important method of progression in the training of muscle power. As the power of the muscle increases, the resistance or weight which is to be overcome must also be increased until such time as no further progression is possible or desirable. As the insertions of muscles constituting the effort factors are at fixed points in relation to the joints, the only factors capable of variation are the weight and its perpendicular distance from the fulcrum. Added resistance to the muscle action can therefore be applied, either by increasing the poundage of the weight to be overcome or by increasing the length of the weight's arm. The latter is usually referred to as increasing the leverage.

Increasing the leverage is concerned with the situation of the point of application of a given weight. For example: Abduction of the arm at the shoulder joint with the elbow flexed reduces the leverage, and relatively weak muscles can perform the movement, whereas when the elbow is straight and the leverage is increased a more powerful contraction is required. This can be demonstrated in the case of Deltoid paresis, with the patient sitting and with the shoulder girdle fixed. Similarly, the situation of an external resistance, be it manual or mechanical, will dictate the muscular effort required to overcome it. For example: A known resistance given at the level of the knee joint is more easily overcome by the extensors of the hip than the same resistance applied at the foot when the knee is straight.

ANGLE OF PULL

A force is most effective when it is applied at right angles to a lever.

Mechanical Efficiency of a Muscle

Mechanically, the pull is most efficient when the muscle is inserted at right angles to the bone. This efficiency is decreased as the angle of pull is reduced, because some of the force is used in pulling the bone of insertion towards the joint representing the fulcrum. This approximation of the articular surfaces has a stabilising effect upon the joint which is greatest when the direction of the pull of the muscle is longitudinal, i.e. in the long axis of the bone of attachment. The mechanical efficiency of the muscle pull is also reduced when the angle of insertion

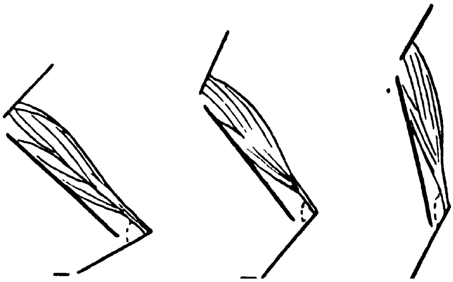


FIG. 18. The length of the muscle is the same in each case. Which foot will gain maximum efficiency from the pull and which ankle is the most stable?

is increased from the right angle. In this case the joint becomes less stable as the angle increases.

Efficiency of a Resistance

The sustained pull of a force offering resistance will also be maximal when it is applied at right angles to a lever, and will dccrease as the angle of pull becomes acute or obtuse.

A force offering resistance to movement of one of the body levers

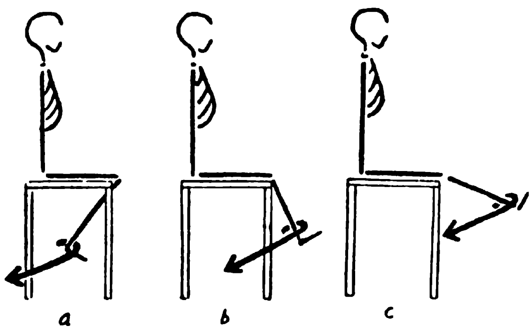


FIG. 19. The effect of the resisting force is maximal when it is applied at right angles (*b*)

may be applied by means of a rope or through the physiotherapist's hand. The effect of this resisting force is maximal when it is applied at right angles to the moving bone. During the course of a movement, when the angle of pull must vary, the right-angled pull is employed in that part of the range in which maximum resistance is required. This usually coincides with the part of the range in which the pull of the working muscles is most efficient.

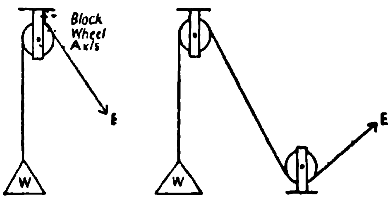
PULLEYS

A pulley is a grooved wheel which is rotated about a fixed axis by a rope which passes round it. The axis is supported by a framework or block, and the whole structure may be used either as a fixed pulley or a movable pulley.

The Fixed Pulley

This is used to alter the direction of a force, and enables traction or resistance to be applied at any angle. The pulley block is fixed to some suitable support and the rope which passes round the wheel is attached to the weight at one end and the effort is applied at the other.

Single Fixed Pulley



Two Fixed Pulleys

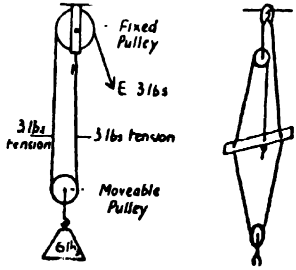
FIG. 20

Something analogous to the fixed pulley system is used in the body by some muscles to allow them to be inserted at a more advantageous angle, e.g. Digastric and Omohyoid Muscles pull round fibrous loops, and Obturator Internus Musc turns at a right angle and glides on a ridged groove to its insertion.

The Movable Pulley

This device is used to gain a mechanical advantage when lifting heavy weights. One simple combination is in common use for lifting

Theoretical



As used in Physiotherapy for suspension

FIG. 21. Combination of Fixed and Movable Pulleys

the trunk for Suspension exercises. The upper pulley is fixed to an overhead support, to which one end of the rope is attached. The rope is then wound round the movable pulley, to which the weight is attached, and round the fixed pulley, the effort being applied at the free end.

Provided the effect of friction is omitted, the tension is the same in all parts of the rope, therefore, if the weight (W) is 6 lbs. the tension required in each of the two supporting ropes will be 3 lbs. and the effort (E) required will be 3 lbs. This can be expressed as:—

$$\text{Mechanical Advantage} = \frac{W}{E} = \frac{6 \text{ lb.}}{3 \text{ lb.}} = 2$$

If double pulleys are used the effort required can again be reduced by half.

PENDULUMS

By definition, a simple pendulum is a heavy particle, suspended by a weightless thread and free to move to and fro.

When the pendulum is at rest, the thread (or rope) is vertical, but if the particle (or weight) is drawn to one side and then released, the pendulum will swing to and fro. One complete swing in each direction is called an oscillation, and the extent of the swing to any one side from the vertical is the amplitude.

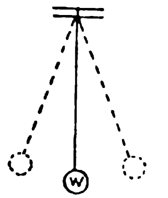


FIG. 22

A force is required to set the pendulum in motion and then the oscillations will continue until it is brought to rest, suddenly, by an opposing force, or progressively, by the resistance of the air, etc. The time taken for each oscillation is determined by the length of the pendulum and the acceleration due to gravity.

Pendular Movement

Pendular movements in the body occur chiefly at the shoulder and hip joints when the muscles are relaxed and the limb distal to the joints swings loosely to and fro. Muscular contraction may be used to initiate the movement and to maintain or increase the amplitude of the oscillations, but it is minimal compared with that required to perform the same movement at any speed greater or less than that of the pendular swing.

For example, the leg is carried forward by a pendular swing of the leg from the hip joint during slow easy walking and the same type of movement occurs to some extent at the knee. Arm-swinging exercises at natural speed can also be done in cases of marked muscular weakness without fatigue, when slow or rapid movement is impossible.

Movement in 'Axial' Suspension

A limb, supported by ropes suspended from a point vertically above the joint to be moved, is said to be in axial suspension, i.e. the point of suspension is vertically above the axis of movement. When the limb is relaxed, it will rest with the joint in the neutral position and, when movement is initiated, it will swing freely to either side of this resting position on a plane which is horizontal.

The arc of movement forms a segment of the base of a cone, the radius of which is equal to the length of the limb and the height of which is equal to the perpendicular distance between the joint and the point of suspension.

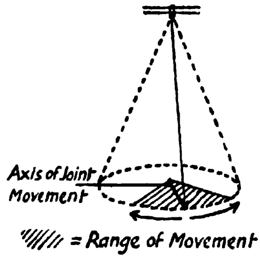


FIG. 23

The advantage of this type of suspension is that the limb can remain fully supported throughout a wide range of movement. This support, which renders the limb gravity free and therefore weightless, aids relaxation during passive movement and relieves the physiotherapist from the necessity of supporting what may be a heavy part of the body, thus freeing her hands for a more accurate performance of the movement. Rhythmical active movement in suspension at a suitable speed is pendular in character and the muscle work required to maintain it is minimal, the effect being to promote reciprocal relaxation and to increase the circulation in the region of the joint which is moved.

Movement in 'Pendular' Suspension

This type of suspension represents merely a lateral or medial displacement of the point of suspension from the position which it occupies in axial suspension. In these circumstances the limb no longer rests in the neutral position of the joint, but falls to a new resting position which lies towards the vertical plane containing the new point of suspension and the joint in question. Movement on either side of this resting position causes the centre of gravity of the limb to rise, making possible pendular movement. Thus, in comparison with axial suspension, the muscle work required to produce movement away from the resting position is increased, but none is required for the return movement.

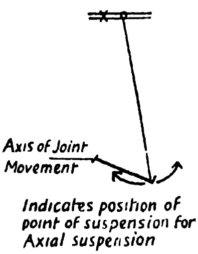


FIG. 24

The effect of this type of suspension upon movement from the resting position is similar to that of an inclined re-education board, which supports the limb during movement up the incline, but differs from it in that, in pendular suspension, friction is virtually eliminated.

For demonstration purposes movement of the lower limb at the hip joint provides a convenient example. Suspension of the limb from a point vertically above the hip joint (Axial Suspension) rests it in alignment with the trunk, and movement into abduction or adduction takes place in a horizontal plane. When the point of suspension is moved medially (Pendular Suspension) the limb falls to rest in adduction, and movement into abduction requires effort and is accompanied by some flexion as the centre of gravity of the limb is raised from the resting position. If the limb is then released it will fall passively into adduction.

Elasticity

Elasticity is the property of a body which enables it to regain its original form after it has been distorted by the application of a force. The latter is known as a *stress* whilst the quantity (e.g. the change in length *per unit length*), which measures the extent of the change in size or shape, is called the *strain*.

Hooke's Law states that:—

The strain is proportional to the stress producing it (so long as the strain is not too great, for once the so-called 'elastic limit' is passed, permanent deformation occurs).

Springs, rubber elastic and Sorbo rubber all possess the property of elasticity, and are in common use in physiotherapy.

Springs

The spiral springs used either to resist or to assist the force of muscular contraction, or to produce passive movement of joints, consist of a uniform coil of wire which is extensible.

The Extensibility of a Spring. A spring can be elongated by a force applied at one end of it in the direction of its long axis, the other end of the spring being fixed. The increase in the length of the spring is directly proportional to the magnitude of the applied force used to stretch it.

The 'Weight' of a Spring. The standard springs which are used are graded, e.g. 50 lbs., 40 lbs., 20 lbs., etc., according to the poundage which must be applied to them to stretch them to a predetermined length. The latter is indicated by a tape inserted within the coils of the spring, the tape becoming taut when the maximum length is reached. The tape also serves to prevent the spring from being overstretched and consequently damaged.

Thus an applied force of 40 lbs. is required to stretch a 40-lb. spring to its maximum length, and any force of a magnitude less than 40 lbs. will stretch it by an amount which is proportional to the magnitude of the force.

The 'weight' of a spring is determined by the material and thickness of the wire from which it is made and the average diameter of its coils.

The Recoil of a Spring. When the applied force which stretches a spring is removed and the spring returns to its original length the potential energy stored in it during extension is released as kinetic energy, and almost all of this appears ultimately as heat in the coils of the spring.

Oscillatory Movement produced by a Spring. If a weight applied to stretch a vertical spring is raised and then released again an oscillatory movement is produced by the spring, the amplitude of which decreases progressively until the spring comes to rest in equilibrium.

Springs used in Parallel. When a spring of a specific weight is not available two equal springs of half the required weight may be used in parallel to produce the same result, e.g. two 40-lb. springs arranged in parallel are equal to a single 80-lb. spring.

Springs used in Series. The weight of two equal springs arranged in series is the same as that of a single spring, but the amount by which

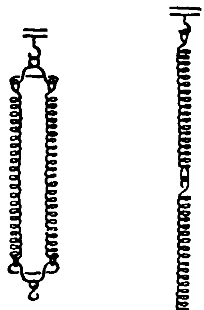


FIG. 25

they must be extended in order to reach the limit of extension is double that required for a single spring. Thus when two 40-lb. springs arranged in series are extended to an amount equal to that required to stretch one of them to the limit, each of the two springs is only half extended, and the applied force needed to achieve this is therefore 20 lbs.

Rubber Elastic

Rubber elastic of different thicknesses may be used in place of springs, and in many ways it is more suitable for providing light assistance or resistance.

Sorbo Rubber

This material is both compressible and extensible and is useful for providing light resistance for gripping movements of the hand.

2

STARTING POSITIONS AND THE PELVIC TILT

MOVEMENT can be initiated from a wide variety of starting or static positions. These positions are maintained by the support of apparatus or by the static contraction of muscles which stabilise the joints. Many have an intrinsic value, in addition to their effect upon the movement which is superimposed upon them.

Selection of suitable positions is made according to the purpose for which they are required. This may be:—

a. To utilise support essential for relaxation.

b. To train correct posture and balance.

c. To achieve adequate fixation when movement is to be localised to a specific joint.

d. To modify the effect of an exercise.

There are five basic or fundamental positions, namely:—standing, kneeling, sitting, lying and hanging. All other positions which are used are modifications of one or other of these five and are therefore known as derived positions, each modification being designed for some specific purpose or effect.

FUNDAMENTAL POSITIONS

1. STANDING (st.)

This is the most difficult of the fundamental positions to maintain, as the whole body must be balanced and stabilised in correct alignment on a small base by the co-ordinated work of many muscle groups. The interaction of the muscle groups concerned is controlled by a complex series of reflexes known collectively as the Postural Reflex. The position may be described as follows—

(*i*) The heels are together and on the same line, the toes slightly apart (so that the angle between the feet does not exceed 45°).

(*ii*) The knees are together and straight.

(*iii*) The hips are extended and laterally rotated slightly.

(*iv*) The pelvis is balanced on the femoral heads at the correct angle (see Pelvic Tilt, p. 26).

(*v*) The spine is stretched to its maximum length.

(*vi*) The vertex is thrust upwards, the ears are level and the eyes look straight forwards.

(*vii*) The shoulders are drawn down and back.

(*viii*) The arms hang loosely to the sides, palms facing inwards towards the body.

It is usually preferable to modify the position of the legs to that in which the heels are slightly apart and the inner borders of the feet are parallel, as this is the natural functional position of the foot when it is used as a lever to propel the body forwards.

Muscle Work. The anti-gravity muscles of the trunk and lower limbs work statically to hold the position. As a method of identifying these muscle groups, let it be supposed that gravity is allowed to act unopposed upon a body in the erect position when all the muscles are progressively relaxed. The result is that the body 'folds up' and falls to the ground. If the anti-gravity muscles, and those which work with them as synergists, are now brought into action the body can be built up to a standing position. The muscle groups involved are—

a. The Intrinsic Muscles of the Feet working to stabilise the feet and to prevent curling of the toes so that the Flexors of the Interphalangeal Joints can press the balls of the toes to the ground.

b. The Plantaflexors of the Ankle, working to balance the lower leg on the foot.

c. The Dorsiflexors of the Ankle, working to counterbalance the action of the Plantaflexors and to support the medial longitudinal arch of the foot.

d. The Evertors, working to counterbalance the action of the Invertors (Tibialis Anterior and Posterior), and in the case of Peroneus Longus, to press the ball of the great toe to the ground.

The interaction of *b*, *c* and *d* may be likened to that of three guy ropes which support a flag pole, the tension in all three is reciprocal, an increase in the tension of one resulting in a slackening of the others. If the pole is perfectly balanced tension in all three is minimal.

e. The Extensors of the Knee may work slightly.

f. The Extensors of the Hip, working to maintain hip extension and to balance the pelvis on the femoral heads. Slight action of the Lateral Rotators of the Hip is associated with a bracing of the legs and of the arches of the foot.

g. The Extensors of the Spine, working to keep the trunk upright. Where their action over the lumbar and cervical regions would result in increased curvature and consequent shortening of the spine, they are counterbalanced by the Flexors of these regions to ensure maximum lengthening.

h. The Flexors of the Lumbar Spine (Abdominal Muscles), working to prevent over-action of the Extensors of this region. They also assist in the maintenance of the correct angle of pelvic tilt, and support the abdominal viscera.

i. The Pre-vertebral Neck Muscles, working to control excessive extension of the neck and to straighten the cervical spine.

j. The Flexors and Extensors of the Atlanto-occipital Joint, working reciprocally to balance the head. The Elevators of the Mandible close the mouth.

k. The Retractors of the Scapulae, working to draw the scapulae backwards so that the glenoid cavity faces more or less laterally.

l. The arms are relaxed. Sometimes, however, it is necessary to use the Lateral Rotators of the Shoulder to keep them in the correct position.

All the muscle groups mentioned above stabilise the body in the antero-posterior direction, in addition there must also be a balanced contraction of the lateral muscles to maintain equilibrium.

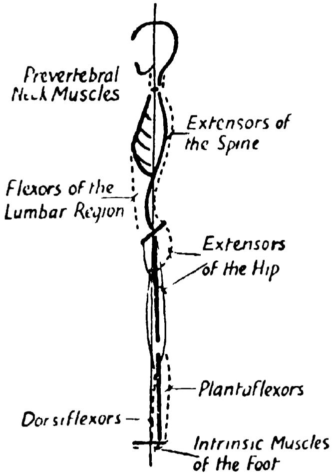


FIG. 26. *standing*

The erect posture has developed during the evolution of man, and it has to be learnt and practised by every child. It is the position of perfect balance which requires the minimum of effort, and therefore the position itself and the muscle work required to maintain it must vary considerably in accordance with the anatomical structure of the individual.

Effects and Uses. As the base is relatively small and the centre of gravity high, the state of equilibrium of the body is relatively less stable than in the other fundamental positions; therefore the standing position is only suitable as a starting position for exercise for those who can maintain it correctly. The muscle work is minimal when perfect balance is achieved, therefore practice in attaining and holding a satisfactory pattern of standing posture reduces fatigue and also conditions the postural reflex. The erect position of the whole body is the position of alertness, in which the thorax is free and the abdominal viscera are well supported; it is associated with a feeling of joy and efficiency, a fact which is demonstrated and recognised in drama and the dance.

2. KNEELING (kn.)

In this little-used position the body is supported on the knees which may be together or slightly apart. The lower leg rests on the floor with the feet plantaflexed, or, if a plinth is used, the feet may be in the mid-position over the edge. The rest of the body is held as in standing.

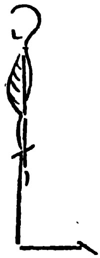


FIG. 27. *kneeling*

Muscle Work. The lower leg is relaxed; the body must be stabilised on the knees.

a. There is interplay between the Flexors and Extensors of the Knee, to balance the femora vertically on the knees.

The muscle work of the rest of the body is as in standing, except that:—

b. The Extensors of the Hip and the Flexors of the Lumbar Spine work more strongly to maintain the correct angle of pelvic tilt. A decrease in this angle and consequent increase in extension of the lumbar spine tends to occur in this position, because of the tension of the Rectus Femoris, which is stretched across the front of both the hip and knee joints.

Effects and Uses. Although the centre of gravity of the body is relatively lower than in standing, the position is only slightly more stable and is uncomfortable for most people. It is, therefore, seldom used except as a starting position for backward movement in a sagittal plane, during which the feet are pressed to the floor by the Extensors of the Knees and Dorsiflexors, so that the lower leg acts as a bracket. As there is a tendency to hollow the back, the position may be of value for patients with 'flat back'.

3. SITTING (sitt.)

The position is taken on a chair or stool, the height and width of which allow the thighs to be fully supported and the hips and knees to be flexed to a right angle. The knees are apart sufficiently to allow the femora to be parallel and the feet rest on the floor with the heels vertically below the knees.

FIG. 28. *sitting*

Muscle Work. There need be no muscle work to hold the position of the legs, as they are fully supported. The Flexors of the Hips work to maintain a right angle at these joints and to prevent the tendency to slump.

The muscle work of the rest of the body is the same as in standing.

Effects and Uses. This is a comfortable, natural and very stable position which is much used, and it is particularly suitable for those who lack the necessary strength and control to maintain a more difficult position. Lateral and rotatory mobility of the pelvis is eliminated by the weight of the body and the position of the legs, so that lateral and rotatory movements can be localised to the spine. As none of the body weight is transmitted to the legs, many non-weight-bearing knee and foot exercises can be performed in the position, which is also suitable for training correct alignment of the upper part of the body in the habitual sitting position, which is used by the majority more than any other in everyday life.

4. LYING (ly.)

This is the easiest of the fundamental positions as the body can be completely supported in the supine position and is as stable as is possible.

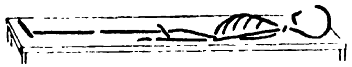


FIG. 29. *lying*

Muscle Work. This is minimal. If the body is relaxed on a hard surface, such as the floor or the average plinth, the head rolls to one side, the lumbar spine is hollowed because of the tension of structures lying anterior to the hip joints and the latter fall into a position of lateral rotation. On a soft resilient surface, however, such as a spring mattress, which gives way to the contours of the body and supports it completely, this does not occur.

When the lying position is used as a starting position for exercise it is usually taken on a firm surface and the following muscle groups work slightly:—

a. The Head Rotators of both sides work reciprocally to stabilise the position of the head.

b. The Extensors of the Hips and Flexors of the Lumbar Spine work to combat the tendency to hollow the back.

c. The Medial Rotators of the Hips work to keep the legs in the neutral position, so that the knees and inner borders of the feet are held together.

Effects and Uses. This is an easy position and as the trunk is relaxed and fixed by its own weight, it is a suitable position for many arm and leg exercises. As the alignment of the body is the same as in standing, static posture training can be carried out in this position once adequate control of the pelvic tilt is established. The spine is relieved of the burden of transmitting the weight of the head and shoulders when it is in the horizontal position, therefore it tends to elongate and straighten, and this is an advantage in the treatment of spinal deformities. Breathing is impeded slightly by pressure on the posterior aspect of the thorax and by increased pressure of the abdominal viscera on the under surface of the Diaphragm, often making the position unsuitable for those suffering from respiratory or heart conditions. The position hinders the return of blood from the head and so may be unsuitable for the elderly, or those who suffer from high blood pressure.

5. HANGING (hg.)

The body is suspended by grasping over a horizontal bar, the forearms being pronated, the arms straight and at least shoulder width apart. The head is held high and the scapulae are drawn down and together, so that the neck appears as long as possible. The trunk and legs hang straight, with the heels together and the ankles plantaflexed.

FIG. 30. *hanging*

Muscle Work

a. The Flexors of the Fingers work strongly to grasp the bar.

b. All the muscles round the wrist work strongly to reduce the strain on the joints and to act as synergists and fixators for the Flexors of the Fingers.

c. The Flexors of the Elbows work to reduce the strain on the joints.

d. The Adductors of the Shoulders work strongly to lift the body on the arms (especially Latissimus Dorsi posteriorly and Pectoralis Major anteriorly).

e. The Depressors, Retractors and Medial Rotators of the Scapulae work strongly to fix the scapulae and to brace the upper back.

f. The Pre-vertebral and Posterior Neck Muscles work reciprocally to maintain the position of the head and neck.

g. The Flexors of the Lumbar Spine and the Extensors of the Hips work to correct the tendency to arch the back as the result of the over-action of Latissimus Dorsi, working on the sacrum.

h. The Adductors of the Hips work to keep the legs together.

i. The Extensors of the Knees may work to maintain full extension.

j. The Plantaflexors work to point the toes to the floor.

Effects and Uses. As the muscle work for the arms and upper back is extensive and strong the position is only suitable for those in whom muscular strength and body weight are well balanced. As the weight of the shoulders is taken off the spine and the weight of the legs exert traction upon it, it is straightened and elongated. This effect is somewhat reduced by the action of Latissimus Dorsi, nevertheless the position is useful in teaching the feeling of correct alignment in cases of spinal curvature.

The thorax is fixed in the inspiratory position and breathing is difficult, therefore the position is unsuitable for weak patients and those suffering from cardiac or respiratory conditions. The effect of stretching the body is stimulating and much enjoyed, especially by children.

For Derived Positions see Appendix, p. 271.

* * *

THE PELVIC TILT

When the body is erect the pelvis is inclined forwards and balanced on the heads of the femora. The angle of this antero-posterior inclination or pelvic tilt is variable and it can be measured in several ways.

Methods of Measuring the Angle of Pelvic Tilt

1. The angle at which an imaginary line, drawn through the symphysis pubis and the lumbo-sacral angle, lies in relation to a horizontal line can be measured. The pelvic tilt is said to be normal in the standing position when this angle measures between 50° and 60°.

2. The angle of pelvic tilt is said to be normai in the standing

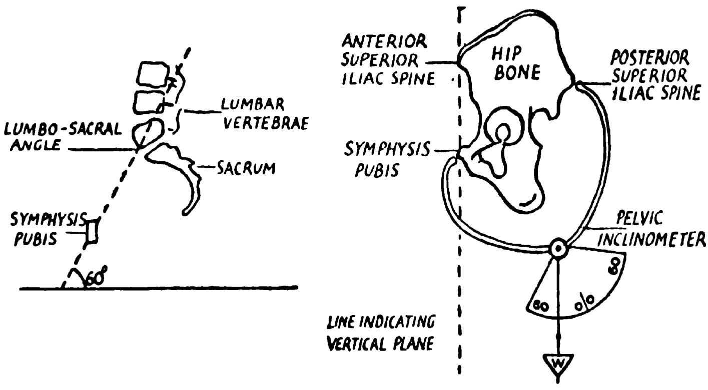


FIG. 31. Measurement of the Angle of Pelvic Tilt (methods 1 *left* and 2 and 3 *right*)

position when the anterior superior iliac spines and the symphysis pubis all lie in the same vertical plane.

3. The angle recorded by a pelvic inclinometer, one of the arms of which is placed over the symphysis pubis and the other over one of the posterior superior iliac spines, is in the region of 30° in the standing position when the pelvic tilt is normal.

Maintenance of the Normal Angle of Antero-posterior Tilt of the Pelvis

The angle of the pelvic tilt in the standing position is stabilised either by the tension of the structures which lie anterior to the hip joint, which prevent the angle from being reduced, or by the action of the straight Abdominal Muscles and the Hip Extensors which prevent it from being increased.

Alteration in the Angle of Antero-posterior Tilt of the Pelvis

An increase in the angle of pelvic tilt may be called forward tilting of the pelvis, and a decrease in the angle of pelvic tilt may be called backward tilting of the pelvis.

Forward Tilting of the Pelvis. Movement of the pelvis on the

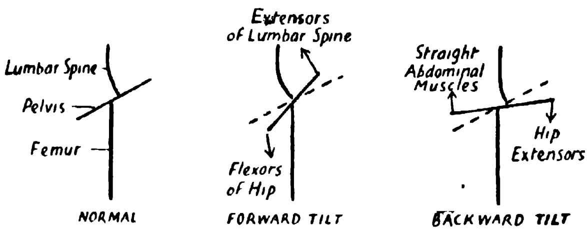


FIG. 32. Antero-posterior Tilting of Pelvis

femoral heads to produce a forward tilting is produced by the contraction of the Hip Flexor Muscles and the Extensors of the Lumbar Spine.

Backward Tilting of the Pelvis. The pelvis can be tilted backwards on the femoral heads by the contraction of the Hip Extensors and the straight Abdominal Muscles.

Lateral Tilting of the Pelvis

The pelvis may also be tilted laterally on one of the femoral heads. When the femur on which the pelvis is tilted is fixed as in standing on

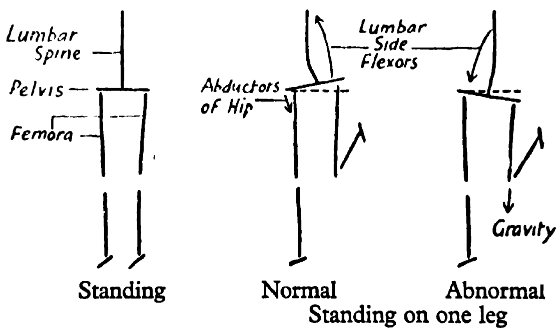


FIG. 33. Lateral Tilting of Pelvis

one leg, and the other leg is free to move, the pelvis is tilted laterally as the result of abduction or adduction in the hip joint of the leg which is fixed. An upward inclination of the pelvis from the point of support is produced by the contraction of the Abductors of the Hip of the supporting leg. When this occurs the Lumbar Side Flexors on the opposite side from the supporting leg usually work to keep the trunk erect.

When the weight of the body is transferred on to one leg and the Hip Abductors are relaxed or inefficient, the pelvis is inclined laterally and downwards towards the unsupported side by the force of gravity.

Rotation of the Pelvis

The pelvis can also be rotated to some extent on the femoral heads. See Chapter 10, p. 160.

3

RHYTHM, TIMING AND DURATION OF MOVEMENT

Rhythm of Movement

The word rhythm means a regular beat or recurrence of a sequence of events.

The inspiratory muscles and the heart muscle contract rhythmically throughout life, their period of contraction alternating with a period of relaxation and inaction.

Skeletal muscles can also work for long periods of time without fatigue, provided their contraction alternates regularly with complete relaxation and consequent replenishment of the blood supply bringing oxygen to repair the effects of contraction and to remove metabolic products. The rhythm of work and rest reduces fatigue to the minimum, e.g. a hiker walking with an even stride rhythmically contracts and relaxes the Extensor Muscles of the legs, and the newcomer to industry is trained in the rhythmical sequence of the movements he is to perform at work.

Each movement has its own natural rhythm which varies to some extent in individuals and according to their anatomical and physiological peculiarities. The natural rhythm also varies with age, the rhythm of children's movement being relatively quick as compared with that of the adult, while that of the very elderly is slower still.

Rhythmical movements taken too quickly or too slowly usually result in faulty timing and loss of efficiency, an increase in the muscle work or a diminution of the range of movement.

Music played at a suitable speed can assist the performance of movement. Popular tunes with a definite beat, and which are easily learnt and remembered, seem to be the most satisfactory as they reduce the boredom of repetitive movements such as marching, typing or scrubbing.

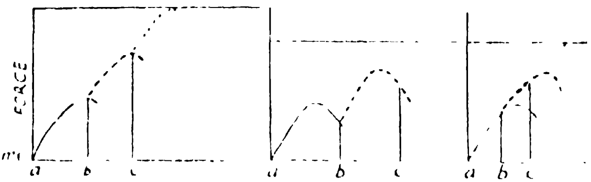
Timing

Timing is a characteristic of skilled movement. Several forces including that of muscular contraction combine to produce movement or to overcome a specific resistance, and it is the proper sequence of the application of these forces which constitutes timing.

Each force utilised must be at its maximum when a subsequent force is superimposed upon it, otherwise the peak of effort reached by that force will be wasted. Thus there is a waste of effort if the sequence *or timing is either too rapid or too slow.*

Skilled and co-ordinated movements, such as walking, running or riding a bicycle, can be analysed and each component movement practised separately, but training is not complete until the sequence of these component movements is correctly timed in order to achieve maximum efficiency. Skills, well learnt, develop into habits and are remembered for a long time.

When a new skilled movement is learned, there is a tendency for



Good timing Timing too slow Timing too fast

FIG. 34

the performance to be too hurried and for some of the component movements to be omitted or replaced by others which involve useless effort and a reduction of efficiency; alternatively the timing may be too slow. In either case much energy is expended with little result, e.g. as in the early stages of learning to swim or play golf.

An attempt to contract a weak muscle may be timed to take place during an otherwise passive movement of the joint over which it works and in that part of the range in which it would be most efficient. In this way the muscle may be encouraged to contract under ideal conditions at an early stage of recovery from paralysis.

DURATION

The duration of a movement, an exercise or a treatment is the time that it lasts.

An increase in the duration of a particular movement results in a reduction of speed, and this affects the amount of muscular effort which is required to perform the movement. A decrease in duration of a similar movement results in an increase in the speed at which it is performed.

The duration of an exercise usually indicates the time during which it is performed at any convenient speed, but it may also specify the number of times the exercise is performed.

Treatments vary in duration according to the nature of the lesion, the capacity of the patient and the time available.

4

CLASSIFICATION, TECHNIQUE AND EFFECTS OF MOVEMENT

THE joints are used to achieve movement and resilience in what would otherwise be a rigid bony framework.

Movement which is produced by an external force, during muscular inactivity, is known as Passive Movement. The types of Passive Movement are as follows—

PASSIVE MOVEMENT
- *a.* Relaxed
- *b.* Forced (or Manipulative)
- *c.* Manipulations

The movement or stability of joints which results from the activity of skeletal muscles may be Voluntary or Involuntary. Voluntary movement is directly under the control of the will and is known as Active Exercise. Active Exercise may be classified thus—

ACTIVE EXERCISE (*Voluntary Movement*)
- *a.* Free
- *b.* Assisted
- *c.* Resisted

Involuntary movement which is the result of the activity of skeletal muscles is not directly under the control of the will. Two types require some explanation.

ACTIVE EXERCISE (*Involuntary Movement*)
- *a.* Reflex
- *b.* Associated

The activity of involuntary muscle is never under the control of the will.

PASSIVE MOVEMENT

Definition

Movements which are produced by an external force during muscular inactivity.

Classification

Relaxed Passive Movements. A state of relaxation is presupposed, and the joint is moved through the existing free range, and within the limits of pain.

Forced (or Manipulative) Passive Movements. Where movement in a joint is limited, these movements are carried beyond the existing free range, in an attempt to restore the normal range by—

(*i*) a sudden but controlled application of force at the limit of the existing range, or by

(*ii*) a steady and sustained passive stretching of the tightened structures.

Manipulations. These are forced movements performed by a surgeon, when the patient is relaxed by means of a general anaesthetic, or when the local pain receptors are anaesthetised by injection. They are designed to break down consolidated adhesions.

a. Relaxed Passive Movements

The physiotherapist requires much control and a knowledge of joint anatomy to perform the movements for the patient smoothly and with accuracy.

Technique

Relaxation. A brief explanation of what is to happen is given to the patient, who is then taught to relax voluntarily, except in cases of flaccid paralysis when this is unnecessary. The selection of a suitable starting position ensures comfort and support, and the bearing of the physiotherapist will do much to inspire confidence and co-operation in maintaining relaxation throughout the movement.

Fixation. Where movement is to be limited to a specific joint, the bone which lies proximal to it is fixed, to ensure that the movement is localised to that joint; otherwise any decrease in the normal range is readily masked by compensatory movements occurring at other joints in the vicinity.

Support. Full and comfortable support is given to the part to be moved, so that the patient has confidence and will remain relaxed. The physiotherapist grasps the part firmly but comfortably in her hand, or it may be supported by axial suspension in slings. The latter method is particularly useful for the trunk or heavy limbs, as it frees the physiotherapist's hands to assist fixation and to perform the movement. The physiotherapist's stance must be firm and comfortable. When standing, her feet are apart and placed in the line of the movement.

Traction. Many joints allow the articular surfaces to be drawn apart by traction, which is always given in the long axis of a joint, the fixation of the bone proximal to the joint providing an opposing force to a sustained pull on the distal bone. The stretching effect on the periarticular structures facilitates movement.

Movement. Movement is performed for the patient by the physiotherapist, the pattern being that of the natural free movement.

Range. The range of movement is as full as the condition of the joint permits without eliciting pain or spasm in the surrounding muscles. In normal joints slight overpressure can be given to ensure full range, but in flail joints care is needed to avoid taking the movement beyond the normal anatomical limit.

Speed and Duration. As it is essential that relaxation be maintained throughout the movement, the speed must be uniform, fairly slow and rhythmical. The number of times the movement is performed depends on the purpose for which it is used.

Effects and Uses of Relaxed Passive Movements

(*i*) Adhesion formation is prevented and the present free range of movement maintained. One passive movement, well given and at frequent intervals, is sufficient for this purpose, but the usual practice is to put the joint through two movements twice daily.

(*ii*) When active movement is impossible, because of muscular inefficiency, these movements may help to preserve the memory of movement patterns by stimulating the receptors of kinaesthetic sensation.

(*iii*) When full-range active movement is impossible the extensibility of muscles is maintained, and adaptive shortening prevented.

(*iv*) The venous and lymphatic return may be assisted slightly by mechanical pressure and by stretching of the thin-walled vessels which pass across the joint moved.

Relatively quick rhythmical and continued passive movements are required to produce this effect. They are used in conjunction with elevation of the part to relieve oedema when the patient is unable, or unwilling, to perform sufficient active exercise.

(*v*) The rhythm of continued passive movements can have a soothing effect and induce further relaxation and sleep. They may be tried in training relaxation and, if successful, the movement is made imperceptibly and progressively slower as the patient relaxes.

b. Forced (or Manipulative) Passive Movements

These movements aim at increasing the existing range of movement in a stiff joint by tearing or stretching the limiting structures.

Technique

This is similar to that described for the previous type of movement but differs from it in range and speed. Increase in range may be achieved in two ways, in both of which fixation and accuracy of movement are of major importance, and traction is often maintained throughout the movement.

1. The resistance of the limiting structures may be overcome by

a sudden forceful overpressure at the limit of the movement. This *must be done once only, with care and control, to ensure that it actually takes place in the direction required and that it is not carried too far.* The patient must try to remain relaxed, but the sudden stretching and the pain which results will inevitably elicit spasm, and trauma to the muscles may occur. Some exudation into the periarticular structures will result from the stretching and tearing of adhesions; therefore measures must be taken subsequently to ensure its absorption and to maintain the newly won range of movement, otherwise more adhesions will form.

This type of forced passive movement should only be performed under the direct supervision of the doctor unless the physiotherapist is experienced in their use.

2. Steady and sustained traction on shortened muscles and ligaments may succeed in lengthening these structures without traumatising them. Any passive stretching of a muscle beyond the middle range will elicit a reflex contraction known as the myotatic, or stretch, reflex which will protect the underlying fibrous structures from strain. If, however, the stretching is steady and prolonged, the muscle relaxes and the fibrous structures take the strain. The collaginous fibres of which these structures are composed are strong, inelastic and inextensible in response to an intermittent and moderate degree of tension, but give way and elongate when submitted to prolonged strain. Mechanical means such as a turnbuckle plaster, balanced traction and splintage are examples of sustained passive stretching, but more temporary methods, such as head and limb traction or manual stretching, prove effective.

Effects and Uses of Forced (or Manipulative) Passive Movements

(*i*) Recently formed adhesions can be broken down by sudden forceful overpressure exerted at the limit of the free range of movement, which is thus increased.

(*ii*) Accessory movements which cannot be localised actively, but which normally contribute to the function of the joint in which they take place, or that of adjacent joints, can be freed passively: for example, movements at the intercarpal joints which take place during wrist movements, or movement at the subtaloid joint during inversion and eversion of the foot.

(*iii*) A sudden forceful movement when the joint is distracted may replace or alter the position of an interarticular structure.

(*iv*) A steady and prolonged passive stretch can overcome the resistance of shortened ligaments, fascia, and fibrous sheaths of muscles as, for example, in manipulative stretching and the progressive splintage of talipes equino-varus.

c. Manipulations

These are performed by the surgeon with the patient under a general or local anaesthetic, which eliminates pain and protective spasm and allows the use of greater force. Even well-established adhesions can be broken down; but when these are numerous, it is usual to regain full range progressively, by a series of manipulations, to avoid excessive trauma and marked exudation. Maximum effort on the part of the patient and the physiotherapist must be exerted after manipulation to maintain the range of movement gained at each session, otherwise fibrous deposits from the inevitable exudation will form new adhesions.

ACTIVE EXERCISE

(*Voluntary Movement*)

Definition

Movement performed or controlled by the voluntary action of muscles, working in opposition to an external force.

Classification

Free Exercise. The working muscles are subject only to the forces of gravity acting upon the part moved or stabilised.

Assisted Exercise. When muscle power or co-ordination is inadequate to overcome the resistance of gravity or another external force, it can be augmented by the use of an external force applied in the direction of the muscle pull to perform movement or to stabilise a joint.

Resisted Exercise. The forces of resistance offered to the action of the working muscles are artificially and systematically increased to develop the power and endurance of the muscles.

a. Free Exercise

Free exercises are those which are performed by the patient's own muscular efforts without the assistance or resistance of any external force, other than that of gravity. They vary widely in character and effect, not only because of the nature and extent of the movement, but according to the manner in which they are performed.

This type of exercise can be used to obtain any of the effects which are produced by exercise as a whole, if and when it is used judiciously. A degree of relaxation is induced by exercises which are rhythmical or pendular in character; muscle tone is maintained and power increased according to the speed, leverage and duration of the exercise, and the relationship of the part moved to gravity; co-ordination is trained or improved as the natural pattern of group action is employed, and confidence in the ability to perform and control movement is established.

Success in achieving the required effect depends not only on the selection of a suitable exercise and on the manner in which it is performed, but also on the degree of co-operation obtained from the patient and the skill of the instructor.

The great advantage of free exercises lies in the fact that once the patient has mastered the technique of their performance and is aware of their purpose, they are his own, to practise when and where he pleases. He has, in fact, been given the means to cure or to help to cure himself and need no longer rely on others for this purpose.

Whether or not he uses the exercise for home practice to help himself largely depends on his desire for rehabilitation and his confidence in the efficacy of the exercises.

Classification of Free Exercises

Free exercises may be classified according to the extent of the area involved; they may be—

a. Localised
b. General.

a. Localised exercises are designed primarily to produce some local and specific effect, for example, to mobilise a particular joint or to strengthen a particular muscle group. Movement is localised to one or more joints, either by the use of a suitable starting position, or by voluntary fixation of other areas by the patient's own muscular effort.

b. General exercises usually involve the use of many joints and muscles all over the body and the effect is widespread, for example, as in running.

The character of a particular exercise may be—

a. Subjective
b. Objective.

a. Exercises which are subjective are usually formal and consist of more or less anatomical movements performed in full range. The attention of the patient is deliberately focused on the form and pattern of the exercise to ensure accuracy of performance, e.g. *sitting; Arm bending and stretching sideways and upward.* As many of these exercises are artificial and bear little relation to natural movement, these are now used to a lesser degree than formerly. Some, however, are undoubtedly useful in establishing a correct pattern of movement and in avoiding the tendency to develop 'trick' movement, which is often functionally effective but wasteful of energy in comparison with the correct movement.

b. Objective exercises are those during the performance of which the patient's attention is concentrated on the achievement of a particular aim which will result from his efforts, e.g. *standing; Arm stretching upwards*, to touch a mark on the wall, or to throw a ball. The presence of a goal to be reached is stimulating to effort, like the proverbial carrot held in front of the donkey's nose, but care must be taken to see that the accuracy of the movement is not sacrificed to the achievement of the aim; e.g. in walking across a room to get a cup of tea, the quality of the walking must not be allowed to deteriorate.

The Technique of Free Exercises

1. The starting position is selected and taught with care to ensure the maximum postural efficiency as a basis for movement.

2. Instruction is given in a manner which will gain the interest and co-operation of the patient and lead him to understand both the pattern and the purpose of the exercise (See Chapter 17, 'Instructing the Patient', p. 265.)

3. The speed at which the exercise is done depends on the effect required. It is usually slow during the period of learning and later the patient is either allowed to find his own natural rhythm, or the speed required is dictated by the physiotherapist. It often helps the patient to maintain his natural rhythm at home if, during practice under supervision, he is encouraged to count aloud.

4. The duration of the exercise depends very largely on the patient's capacity. Usually three bouts of practice for each exercise, with short rest periods, or a change of activity, between, ensure sufficient practice without undue fatigue.

The Effects and Uses of Free Exercise

The effect and consequent uses of any particular free exercise depend on the nature of the exercise, its extent and the intensity and duration of its performance.

Relaxation. Rhythmical swinging movements and those which are pendular in character assist the relaxation of hypertonic muscles in the region of the joint moved. The alternating and reciprocal contraction and relaxation of the opposing muscle groups, which is required to sustain the movement, helps to restore the normal state of relaxation which follows contraction. This type of exercise is used in conjunction with other methods which induce relaxation to reduce a state of wasteful tension in muscles, which limits the range of joint movement and reduces the efficiency of neuromuscular co-ordination.

Exercises which work a particular muscle group strongly achieve a reciprocal relaxation of the opposing group, e.g. work for the Scapular Retractors and Shoulder Extensors assists relaxation of the Pectoral Muscles.

Joint Mobility. The normal range of joint movement is maintained by exercises performed in full range. If and when the range of movement is limited, rhythmical swinging exercises incorporating overpressure at the limit of the free range may serve to increase it.

Muscle Power and Tone. The power and endurance of the working muscles are maintained or increased in response to the tension created in them. This tension is greater when the exercise is performed at any speed which is slower, or more rapid, than when the natural speed of movement is employed, and it increases with the duration of the exercise. A high degree of tension and consequent increase in power can be developed by free exercises when the muscles work for any time against the resistance offered by the body weight, or against the mechanical disadvantage of an adverse leverage provided by a long and heavy limb.

Normally, muscle power is maintained adequately by a minimum of everyday activities, most of which are performed in the middle range. Under abnormal conditions, however, for example during fixation of a joint, the power can only be maintained or improved by repeated static contractions, which the patient must practise throughout the day.

Neuromuscular Co-ordination. Co-ordination is improved by the repetition of an exercise. As the pattern of movement is established, it is simplified and becomes more efficient, and the conduction of the necessary impulses along the neuromuscular pathways is facilitated. Exercises or activities, which at one time required concentration and much effort, become with practice more or less automatic in character, and skill is developed, as for example in walking or playing the piano.

Confidence. The achievement of co-ordinated and efficient movement assures the patient of his ability to maintain subjective control of his body, giving him confidence to attempt other and new activities, together with a feeling of exhilaration and satisfaction when they are accomplished, for example, jumping a rope, or shooting a goal. Objective exercises and activities are usually used for this purpose.

Circulatory and Respiratory Co-operation. During vigorous or prolonged exercise it is apparent that the speed and depth of respiration is increased, that the heart beat is faster and more forceful, and that heat is produced, whereas in light exercise these changes are so slight that they are not noticed.

a. The Needs of the Active Tissues. The active tissues involved during muscular exercise require a free supply of oxygenated blood and the removal of metabolic products to enable them to continue their activity. To meet these demands and to keep pace with them, the co-operation of the Circulatory and Respiratory Systems is enlisted.

b. Preparation for Activity. It is probable that the cerebral cortex, which initiates the muscular contraction, also prepares the body to supply the needs of the tissues concerned, by communicating with the Respiratory, Cardiac and Vaso-motor centres which form part of the Autonomic Nervous System. Sympathetic fibres from these centres convey impulses to the appropriate organs which, with the help of adrenalin, which is released into the blood stream, produce widespread results. These results include increased respiration, increased frequency of the heart beat, a rise in arterial blood pressure, and a re-distribution of blood, so that the volume of blood in the muscles is increased at the expense of that in the splanchnic area and the skin.

All these changes occur merely as the result of the anticipation of exercise as those who have taken part in competitive sports may have been aware.

c. Local Circulatory Changes in the Muscles. During active exercise the capillaries in the working muscles dilate and their permeability is increased. Many capillaries that were closed when the muscle was at rest become open and blood flows through them. In this way the capacity of the muscles to contain blood is markedly increased and the interchange of fuel and waste products between the blood and the tissue fluids is facilitated.

d. Regulation of Circulatory and Respiratory Function during Exercise. The venous return to the heart is increased during exercise and results in an increase in cardiac output. The increased venous return is caused partly by the pressure variations in the abdominal and thoracic cavities resulting from increased respiratory movements which exert a pumping action upon the large veins in the direction of the heart, and partly by the pressure of the contracting muscles on the thin walls of the peripheral veins. Valves in these veins prevent regurgitation during relaxation of the pressure.

Muscular contraction increases both the carbon dioxide content and the temperature of the blood, and both these factors stimulate the circulatory and respiratory systems to further activity. The rise in temperature of the body is kept within normal limits by dilatation of the skin capillaries and stimulation of the sweat glands, thus enabling heat to be lost from the surface.

Active exercise can therefore be used to increase Respiration, to increase both the local and the general Circulation, and to provide work for the Heart Muscle.

The effect of active exercise as a whole is so widespread and varies so much in intensity according to the nature of the exercise that it has been described here only in the briefest outline.

b. Assisted Exercise

The Principles of Assistance

When the force exerted on one of the body levers by muscular action is insufficient for the production or control of movement, an external force may be added to augment it. This external force must be applied in the direction of the muscle action but not necessarily at the same point, as a mechanical advantage can be gained by increasing the leverage. The magnitude of this assisting force must be sufficient only to augment the muscular action and must not be allowed to act as a substitute for it, for if it does a passive movement results. As the power of the muscle increases, the assistance given must decrease proportionally.

Technique

The general plan is to ensure that the inefficient muscles exert

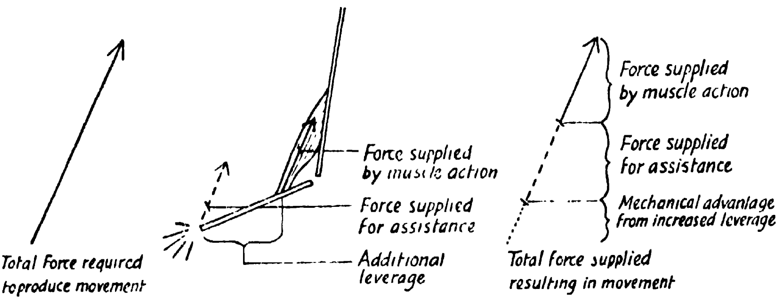


FIG. 35. An External Force is utilised to supplement the Force of Muscular Contraction

their maximum effort to produce movement under conditions designed to facilitate their action. The assisting force is applied only to augment this maximum effort and not to act as a substitute for it.

1. *Starting Position.* Comfort and stability for the body as a whole ensure that the patient's whole attention is concentrated on the pattern of movement and the effort required to perform it.

2. *Pattern of Movement.* This must be well known and understood by the patient. It can be taught by passive movement or in the case of limb movements by active movement of the contralateral limb.

3. *Fixation.* Adequate fixation of the bone of origin of the prime movers improves their efficiency. Whenever possible this fixation should be achieved by active means in order that the weak muscles may receive reinforcement from the action of those muscles with which they normally associate for the production of voluntary movement. When there is a tendency for movement to be transferred to neigh-

bouring joints to compensate for the inefficiency of the weak muscles, movement in these joints must be controlled or 'held back' by manual pressure or other means of fixation, so that the movement is pivoted at the required joint.

4. *Support.* The part of the body moved is supported throughout to reduce the load on the weakened muscles by counterbalancing the effects of the force of gravity. This support may be provided by the physiotherapist's hands, suspension slings, a polished horizontal surface such as a re-education board, the buoyancy of water or ball-bearing skates. The advantage of manual support is that it can be effective in whichever plane is most suitable for the movement.

5. *The Antagonistic Muscles.* Every effort must be made to reduce tension in the muscles which are antagonistic to the movement. This may be achieved by a variety of methods, e.g. heat, massage, stretching or relaxation techniques; the starting position for the movement should be chosen to ensure that tension in these muscles is minimal, e.g. a position in which the knee is flexed is suitable for assisted dorsiflexion of the foot.

6. *Traction.* Preliminary stretching of the weak muscles to elicit the myotatic (stretch) reflex provides a powerful stimulus to contraction and traction maintained throughout the movement helps to facilitate joint movement.

7. *The Assisting Force.* The force used to augment the action of the muscles is applied in the direction of the movement, preferably by means of the physiotherapist's hands, which should be placed in such a way that they rest on the surface of the patient's skin which is in the direction of the movement. In some cases the patient's own hands may be substituted for those of the physiotherapist, provided he thoroughly understands the procedure.

The range of movement is as full as possible, but as the power of muscles varies in different parts of their range more assistance will be necessary in some parts than in others. In general, most assistance is required to overcome the initial inertia at the beginning of movement and at the end to complete the range. In the treatment of stiff joints overpressure may be given at the conclusion of the movement in an attempt to assist the muscles to increase the free range against the tension of limiting structures. The assistance provided by mechanical means varies in different parts of the range according to definite physical laws and therefore it cannot be adjusted to meet the precise requirements of the muscles, with the result that their maximum effort is rarely elicited and all too frequently the movement becomes passive in character.

8. *The Character of the Movement.* The movement is essentially smooth as this is characteristic of efficient voluntary movement and

it is performed in response to a forceful command which demands the patient's full attention. The speed of movement depends on the muscles involved as each has its own optimum rate of contraction which varies according to its structure and the load. Generally speaking fusiform muscles contract rapidly and multipennate ones take longer. Very weak muscles cannot be expected to produce a sustained contraction and therefore assistance is given 'in step' with the contraction which may only be evident as a flicker in the early stages but as power increases the speed of the movement can be decreased.

When assisted exercise is used to increase the range of joint movement the natural rhythm which ensures the fullest possible range is most satisfactory together with an effort to increase the range with timed overpressure in the rhythm of the movement. The rapid movement sometimes advocated either results in a reversal of the movement before the limit of the range is reached or the momentum gained is so great that it eliminates the necessity for muscle contraction and results in jarring of the joint from what is virtually a forced passive movement.

9. *Repetitions.* The number of times the movement is repeated depends on whether it is considered advisable or injurious to fatigue the muscles in question; therefore the condition which has caused the weakness must be known and understood. In the case of stiff joints where there is no joint lesion and the muscles are weak from disuse the movement can be continued as long as the patient can be persuaded to make the effort to improve the range.

10. *The co-operation of the patient* is essential during this type of exercise, the aim being for him to achieve controlled active movement without assistance. Concentrated effort is needed to encourage the muscles to do all they can to help the movement, so praise, well earned, should not be stinted. The ability to see results and to feel what is happening is a great help to the patient so he can be encouraged to palpate his muscles as they contract and the use of a mirror to observe results may be helpful especially when co-ordination is poor.

Effects and Uses of Assisted Exercise

(*i*) The working muscles co-operate in the production of movement which they are incapable of achieving unaided. Provided the maximum effort of which they are capable is demanded from the weak muscles and the assisting force utilised is only complementary, these muscles will gain in strength and hypertrophy.

This type of exercise may be used in the early stages of neuromuscular re-education during recovery from flaccid paralysis.

(*ii*) The memory of the pattern of co-ordinated movement is stimulated by the correct performance of a movement which the patient is unable to achieve without assistance. By frequent repetition of the correct pattern with decreasing assistance, the patient may re-learn to control the movement himself as the conduction of impulses is facilitated in the neuromuscular pathways.

Assisted exercise may therefore be helpful in training co-ordination.

(*iii*) Confidence in the ability to move painful joints is established when the patient observes the movement and the fact that his muscles co-operate in producing it. The contraction of the agonists also ensures reciprocal relaxation of the antagonistic muscles which would otherwise tend to go into protective spasm because of pain or the fear of it. The knowledge that the limb is supported throughout and that it can be rested at any point during the movement encourages the patient to attempt a wider range.

When movement must be maintained in spite of pain in joints these exercises are very useful, e.g. in Rheumatoid Arthritis.

(*iv*) The range of joint movement may be increased by assisted exercise; however, as both range and control are often dependent on the efficiency of the muscles working over that joint, a technique which utilises resisted exercise for these muscles is usually preferable. Where overpressure is given in an attempt to increase the range, results are probably achieved by the repeated mechanical stretching of the soft structures limiting the movement.

c. Resisted Exercise

The Principles of Resistance

An external force may be applied to the body levers to oppose the force of muscular contraction. Tension is increased within the muscles by the opposing force (or resistance) and the muscles respond by an increase in their power and hypertrophy. As the increase in muscular development occurs in response to the increase in intra-muscular tension it follows that the application of the maximum resistance which is consistent with the ability of the muscles to overcome it will elicit the maximum development.

When applying resistance the power of the muscles must always be greater than the resisting force in order to allow contraction and controlled movement to take place (*a*). When the muscle power and the resisting force are equal maximum tension is created in the muscles but no movement results (*b*); but, if the resisting force exceeds the power of the contracted muscles to which it is opposed, it will force the muscles to elongate at a speed which is beyond their control (*c*). This may injure the muscles or the joint and is to be avoided.

There are five factors which contribute to the development of muscular efficiency, i.e. power, endurance, volume, speed of contraction and co-ordination. The first three are inter-related and can be built up by the use of resisted exercise.

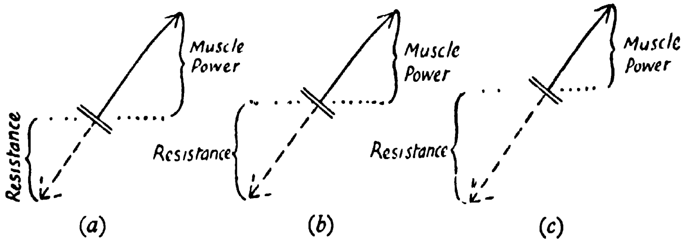


FIG. 26

Power develops in response to the application of the maximum resistance which is consistent with the ability of the muscles to overcome it, therefore power can be built up when they work against a progressively increasing resistance. As the essential factor in power development is the magnitude of the resistance the method used to promote it is called HEAVY RESISTANCE–LOW REPETITION EXERCISE, the number of times the movement is repeated being relatively few to allow the resistance to be as great as possible.

Endurance is a quality which develops in response to repetitive contraction, therefore as it is the number of contractions which is the essential factor, the method used in this case is called LIGHT RESISTANCE–HIGH REPETITION EXERCISE.

Volume, which can be observed or measured as an indication of hypertrophy, usually develops in proportion to power. It serves as a means of demonstrating progress to the patient although it is not invariably a reliable indication of successful treatment.

Skill in estimating the capacity of the muscles at every stage of treatment and in matching this with the correct amount of resistance is the keynote to success in the use of resisted exercise.

Variation of the Power of Muscles in Different Parts of their Range

Muscles which are capable of producing a considerable range of joint movement are not equally powerful in all parts of their range.

Physiologically, muscles are capable of exerting their greatest strength when they are fully extended, i.e. in outer range, and as they shorten their force diminishes. This, however, is modified in the case of some muscles by mechanical factors such as the angle of pull of the tendon of insertion, i.e. the effect of the pull on the lever is greatest when the angle of pull approaches a right angle.

For example: physiologically the Flexors of the Elbow are strongest in their outer range, but mechanically strongest at about mid-range. When both these factors are taken into account, and allowance is made *for overcoming the initial inertia at the beginning of the movement, it can be roughly estimated that the muscles will be most efficient in* the outer part of the middle range. This, in fact, can be proved by experiment.

It seems, however, that the relative importance of these factors varies in different muscle groups but, broadly speaking, each group is found to be most powerful in the part of the range in which it is habitually used, i.e. Shoulder Flexors in outer range, Hip Extensors in inner range. In giving manual resistance these variations in power can be felt and the resistance adjusted accordingly, but other means of providing resistance are not so accurate from this point of view.

Technique of Resisted Exercises

1. *Starting Position.* Comfort and stability for the body as a whole ensures that the patient's whole attention can be concentrated on the pattern of movement and the effort required to overcome the resistance.

2. *The Pattern of Movement.* This must be well known by the patient and can be taught as a free exercise. The pattern selected should, whenever possible, be one which allows contraction of the muscles in full range and it should be based on a natural pattern of purposeful movement.

3. *Stabilisation.* Stabilisation of the bone or bones of origin of the muscles to be resisted improves their efficiency. This stabilisation is rarely static when a natural pattern of movement is used as it is constantly being adapted to the circumstances of the movement. Provided the muscles normally responsible for the stabilisation have remained efficient they should be used for this purpose, as their action is considered to provide reinforcement for the muscles producing the movement. If, however, there is a tendency for movement to be transferred to neighbouring joints so that the pattern of movement is altered, then additional means of fixation such as manual pressure or a strap must be used to ensure movement at the required joint.

4. *Traction.* Preliminary stretching of the muscles to elicit the myotatic (stretch) reflex provides a powerful stimulus to contraction, and traction maintained throughout the range facilitates joint movement and maintains tension on the muscles and so augments the effect of the resisting force.

5. *The Resisting Force.* A variety of means may be employed to supply the force used to resist the contraction of the working muscles, e.g. manual pressure, weights, springs, etc., but in every case it should be applied in a manner which ensures that pressure is exerted on the surface of the patient's skin which is in the direction of the movement. The advantage of manual pressure is that it can be adjusted accurately

to match the power of the muscles in all circumstances and in every part of the range, but it also has the disadvantage of not being easily measurable. Mechanical resistances are usually measurable and therefore provide a useful means of recording progress.

The magnitude of the resisting force, in relation to that of the muscle power, varies according to the purpose for which it is used. Maximal resistance elicits maximal effort on the part of the muscles and it is therefore used to develop power and hypertrophy. As the quality of muscular endurance is developed by repeated contraction against resistance the latter is considerably less than maximal to allow a greater number of repetitions to take place.

6. *The Character of the Movement.* The movement is essentially smooth and controlled throughout, the effort involved commanding the patient's full attention. The speed of movement is consistent with the optimum rate of contraction for the particular group of muscles in relation to the resistance which constitutes the load. The range of movement is full whenever possible, but resistance can be applied in any part of the range which is convenient or desirable and the muscles can also be resisted so that they work statically at any particular point in their range.

7. *Repetitions.* The number of times the muscles are thrown into action against a resistance varies according to the condition and the individual patient, and it is inadvisable to accept any rule of thumb procedure.

Low Resistance–High Repetition exercises appear to be more suitable for weak or elderly patients whose muscles are less resilient than those of the young and strong, and they have proved to be effective in such conditions as Osteo-arthritis. High Resistance–Low Repetition exercises on the other hand undoubtedly build up power and hypertrophy muscles suffering from disuse as the result of traumatic injury or in connection with orthopaedic surgery, e.g. menisectomy. When there is effusion or joint changes are present, as in Rheumatoid Arthritis, static resisted contraction of the muscles passing over the joint with a high repetition figure are valuable for retaining muscular efficiency and they can be performed in any part of the range which is pain-free. The number of repetitions may also be determined by the desirability of, or the contraindication to, fatiguing the neuromuscular mechanism in the treatment of a specific condition.

8. *The Co-operation of the Patient.* The effort exerted by the patient and his interest in the treatment undoubtedly play an important part in the development of his muscles by means of resisted exercise. Interest is stimulated by precision in applying the resistance, regular measurement and recording of progress, verbal encouragement and, in suitable cases, by competition.

Resistances

A resisting force other than that provided by gravity and friction may be provided by:—

1. The physiotherapist
2. The patient
3. Weights
4. Weight and pulley circuits
5. Springs and other elastic structures
6. Substances which are malleable
7. Water

1. *Resistance by the Physiotherapist.* This is usually applied manually in the line of the movement. Proprioceptive stimulation facilitates the patient's efforts to overcome the resistance when the physiotherapist's hand is placed on the surface of the skin which is in the direction of the movement. To prevent waste of effort and to ensure smooth controlled pressure the physiotherapist's stance must be in the line of the movement, so that the thrusting action of the legs and the body weight are utilised. Traction may be maintained throughout the

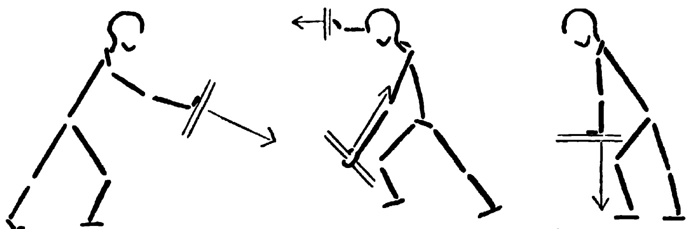


FIG. 37. The Physiotherapist's Stance

movement and the resistance varied according to the variations in power in different parts of the muscle's range, but it cannot be measured accurately or recorded.

2. *Resistance by the Patient.* The patient can resist his own movements with the sound limb, or by tensing the muscles antagonistic to those which attempt to produce the movement, or by using his own body weight. The latter method is probably more accurately classified as a free exercise, but is included here as the quantity of resistance is obviously much greater when, as in this case, the muscles work with reversed origin and insertion to move the trunk on the limbs. This type of resistance is convenient, but tends to be unreliable as it cannot be measured or felt by the physiotherapist and it requires careful instruction and the co-operation and understanding of the patient.

EXAMPLES. From *high sitting* the Extensors of one Knee can be resisted by the weight and pressure of the other leg when the ankles are crossed. The Flexors of the Elbow can be thrown into strong

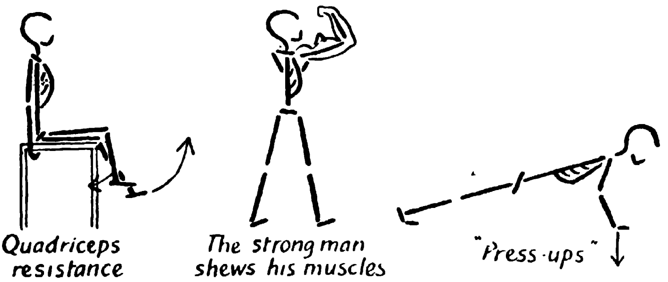


FIG. 38

contraction by bracing all the muscles of the arm. The body can be pressed up from the floor by the arms, if their strength is sufficient.

3. *Resistance by Weights.* The direct application of weights to the body forms a simple and effective method of resisting active exercise. The apparatus required is commonly sandbags, metal weights or a medicine ball, which can be applied by being held in the hand, by attachment to a shoe, or to any other part, by suitable straps. When sandbags or metal weights are used, a canvas bag may be strapped to the part and any number of units of weight can be inserted to provide the required resistance. It is essential that the means of attachment should be comfortable and efficient, but it need not be elaborate.

By this method, resistance must, of necessity, be given in the direction of gravity; its effect increases progressively if the weight is moved

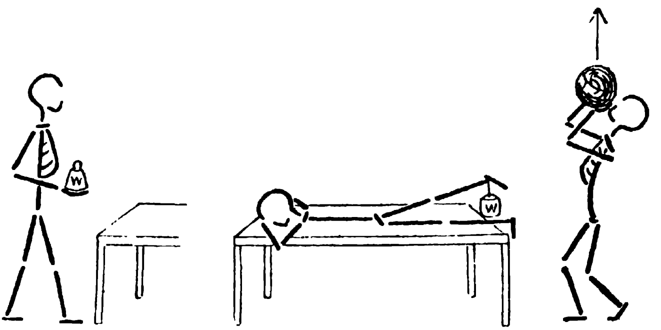


FIG. 39

away from the central axis of the body. It is a convenient method and suitable for home practice after adequate instruction has been given.

EXAMPLES. Lifting a weight held in the hand or attached to the foot or throwing a medicine ball are common examples.

Resistance by weights is also commonly used for the technique known as Heavy Resistance Exercise.

Heavy Resistance Exercise

The use of Heavy Resistance Exercise for the restoration of muscle power and volume after injury was first described by de Lorme in 1945 although this method of promoting muscular development had been well known and used by professional muscle builders for a very long time.

Metal weights, which constitute the resisting force, are applied to the part of the body in question either by means of a bar-bell held in the hand or hands, a de Lorme metal boot or some similar device. The poundage is determined by testing the repetition maximum (R.M.) for a given number of repetitions (page 53). Lifting of the weight may involve either static (isometric) or dynamic (isotonic) muscle work according to the circumstances and the movement is slow and controlled.

Several ways of correlating the weight lifted and the number of repetitions have been used. It appears that the regime most suitable and successful in the treatment of an individual patient varies very much with his age, temperament and the condition from which he is suffering. It is essential that his instruction is precise and that his efforts are well supervised. The following schemes are in common use and form a basis for experiment; they are all based on the test for a 10 R.M. and represent a power programme (page 44).

de Lorme & Watkins

10 lifts with $\frac{1}{2}$ 10 R.M.
10 lifts with $\frac{3}{4}$ 10 R.M.
10 lifts with 10 R.M.

30 lifts 4 times weekly.
Progress 10 R.M. once weekly.

Zinovieff (Oxford Technique)

10 lifts with 10 R.M.
10 lifts with 10 R.M. minus 1 lb.
10 lifts with 10 R.M. minus 2 lbs.
10 lifts with 10 R.M. " 3 lbs.
10 lifts with 10 R.M. " 4 lbs.
10 lifts with 10 R.M. " 5 lbs.
10 lifts with 10 R.M. " 6 lbs.
10 lifts with 10 R.M. " 7 lbs.
10 lifts with 10 R.M. " 8 lbs.
10 lifts with 10 R.M. " 9 lbs.

100 lifts 5 times weekly.
Progress 10 R.M. daily.

MacQueen

10 lifts with 10 R.M.
10 lifts with 10 R.M.
10 lifts with 10 R.M.
10 lifts with 10 R.M.

40 lifts 3 times weekly.
Progress 10 R.M. every 1–2 weeks.

The endurance programme is based on the use of relatively low resistance and high repetition regime.

Heavy resistance exercise can be used in principle for the development of most muscle groups but it is at present more often used for the Knee Extensors than any other group. Some suggestions with regard to suitable positions and methods are therefore described in relation to these muscles on page 137.

4. *Resistance by Weight and Pulley Circuits.* The use of a rope and pulley allows the force exerted by a weight to act in any direction (see Pulleys, p. 15), therefore the muscles need not be required to work against the resistance of both gravity and the weight. The effect of gravity can be counterbalanced if the movement takes place in a horizontal plane. This provides a useful method of arranging resistance for weak muscles when the limb is heavy.

EXAMPLE. In *sitting* the resistance of gravity to the Knee Extensors is approximately 10 lbs. If these muscles are unable to straighten the knee against this resistance, they may still be able to perform the exercise adequately when, in *side lying*, the leg is supported horizontally and a resistance of, perhaps, 8 lbs. is applied.

As the angle of pull of the rope by which it is applied, and therefore the resistance itself, must vary during the course of a movement, a resistance can be offered to the muscles which matches the variation of their power in different parts of the range more accurately than that supplied by means of a weight applied directly to the part or by a spring.

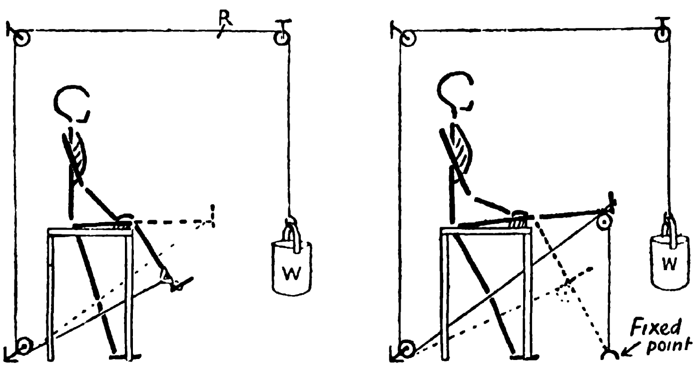


FIG. 40. Two Popular Methods of giving Weight and Pulley Resistance for the Knee Extensors. The relaxation stop R is shown on the left

Assuming that a particular muscle group is most powerful in midrange it is there that the resistance is applied at right angles. Both the power of the muscles and the force of the resistance will diminish on either side of this point.

To ensure relaxation and lack of strain on the joints between movements a *relaxation stop* is incorporated on the circuit by means of a clip or knot which prevents the rope from passing the pulley, or by arranging for the weight to be supported at the end of the movement. Psychologically, it is of the greatest importance for the patient to be able to see the weight moving as the result of his work and to know and record the poundage lifted.

5. *Resistance by Springs and Other Elastic Substances.* The resisting force of a spring increases progressively as it is stretched or compressed according to the type of spring used.

Although convenient to arrange, the use of springs for resisting muscular contraction must be regarded as a somewhat crude method as it is virtually impossible to match their resistance to the capacity of the muscles with regard to both power and range of movement.

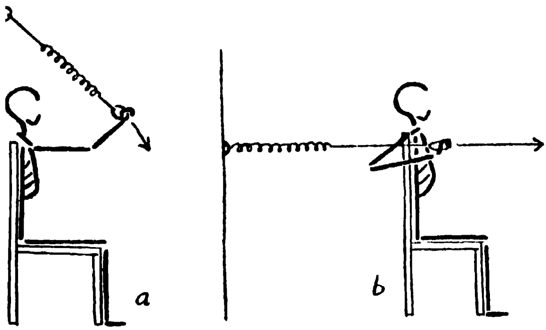


FIG. 41. Spring Resistance for the Elbow Extensors

When springs are used the speed of movement must be carefully controlled by the muscles both in contraction and during controlled relaxation as the accumulated energy in an extended spring makes its natural speed of recoil very great.

Other extensible materials such as rubber elastic of various widths and thicknesses behave in a manner similar to that of springs, but they are not so durable. The elastic properties of Sorbo rubber are apparent on pressure, and rubber sponges, Dunlopillo and rubber balls afford varying resistances which are particularly useful in developing the gripping muscles of the hand.

6. *Resistance by Substances which are Malleable.* Substances such as putty, clay, some kinds of wax, Plasticine and wet sand can be moulded into different shapes. The resistance they offer to this change in form is variable and can be used both for strengthening and for mobilising the hands.

7. *Resistance by Water.* The resistance offered by water increases

with the speed and the surface area of the part moved. When the movement is vertical, buoyancy adds to the resistance on the way down and cancels out much of the resistance on the way up.

Methods of Assessment

Neuromuscular efficiency must be tested before treatment and at specific intervals in order to assess progress and the efficacy of the treatment. A variety of methods may be used, but in every case it is important that the test should be standardised as far as possible, i.e. it should be carried out by the same physiotherapist under conditions which are as nearly similar as possible to those of the previous test. Results must be accurately recorded. The following examples of testing methods are in common use:—

1. *Electrical Tests*

These may be carried out by the doctor with the use of the electromyograph or by means of the strength-duration curve. They are particularly valuable for diagnostic purposes.

2. *The Oxford Classification*

This is the standard most universally employed.

0. No contraction.
1. Flicker of contraction.
2. Weak. Small movement with gravity counterbalanced.
3. Fair. Movement against gravity.
4. Good. Movement against gravity and some resistance.
5. Normal.

3. *Circumference Measurement*

This test relies on the fact that there is a relationship between the development of power and that of hypertrophy. A tape measure made from some inextensible material is used to measure the circumference of the limb at a predetermined level. Experiment on normal limbs indicates that this method is unreliable even in experienced hands; it is still, however, much used.

4. *Static Power Test*

The power of static or isometric contraction may be recorded by means of a spring balance capable of registering up to 50 or 100 lbs. The extensibility of the spring within this type of balance is virtually negligible and it can be arranged in such a way that contraction of the muscle group can take place at any predetermined point within its range. Record can be made of the maximum poundage recorded or of the average poundage recorded as the result of three efforts made at one-minute intervals.

5. *Dynamic Power Test*

This is a method devised by de Lorme and Watkins as a basis for progressive Heavy Resistance Exercise. The maximum weight which can be lifted *once only* through a prescribed range is called the One Repetition Maximum (1 R.M.) and the maximum weight which can be lifted ten times at natural speed without rest between lifts is the Ten Repetition Maximum (10 R.M.). Experience in estimating the approximate weight which can be lifted is essential to avoid fatigue which results from continued trial and error and which rapidly reduces the poundage which can be lifted.

6. *Endurance Test*

Endurance may be calculated by recording the drop in the maximal power of the muscles when their effort of contraction is repeated at given intervals for a specific period of time.

7. *Functional Assessment*

This involves a series of tests designed to estimate the patient's ability to perform the activities of daily living (A.D.L.). Such activities may be grouped under headings, e.g. mobility, personal care, household or garden jobs, work, recreational and social activities.

Progression

As the power of the muscle increases, the tension produced by a resistance which is constant will diminish, therefore, to maintain the stimulus of tension, the resistance must be increased proportionately as the power of the muscle develops.

There are four main methods of increasing resistance to muscle action. Each method may be used singly or in combination with any other method:—

1. Increase in poundage or weight of the resisting force.
2. Increase in leverage of the resisting force.
3. Alteration in the speed of movement.
4. Increase in the duration of the exercise.

1. *Increase in Poundage or Weight.* For example: it is found that a muscle group, able to achieve full-range contraction against a weight of 3 lbs. when it is applied at a specific point, can contract at a specific speed and for a specific duration. As the muscle power increases, the weight is increased proportionately to 4 lbs., 5 lbs. or 6 lbs., while the other conditions remain constant. The actual amount of the increase is variable according to the particular muscle group, its rate of progress to recovery and the frequency at which an increase is made.

2. *Increase in Leverage.* The total resistance offered by a given weight depends on the position of its point of application in relation to the fulcrum. (Moment of Force = Weight × Perpendicular Distance

from the fulcrum.) The greater the perpendicular distance of the point of application from the fulcrum, i.e. the joint at which movement takes place, the greater the resistance offered by the weight. (See p. 13, Levers.)

EXAMPLE. A manual resistance, which is relatively constant, given *to the Shoulder Abductors with the arm straight, is much greater when* applied at the wrist than at the elbow.

3. *Alteration in the Speed of Movement.* Muscular contraction is most efficient when it takes place at an optimum or natural speed. This speed varies according to the form and structure of the muscles concerned, the resistance, and the individual. Increase or decrease in this natural speed of contraction increases the effect of the resistance when the muscle works concentrically, but when it works eccentrically, the slower the movement the greater the effect of the resistance, i.e. concentric work is easiest at natural speed, eccentric work at high speeds.

For example: it is easier to climb a steep hill at your own speed than at one dictated by a companion who may prefer to go faster or slower than you do, but it is easier to come down rapidly.

4. *Increase in the Duration.* As muscles warm up to their task of overcoming a resistance, they become more efficient and therefore the effect of the resistance decreases and the exercise seems easier. If, however, it is continued a sufficient number of times, fatigue reduces the efficiency of the muscles and the resistance therefore appears greater.

For example: sawing a log of wood may seem to become easier as you warm up to it, but it becomes hard work by the end of an hour.

Effects and Uses of Resisted Exercises

(*i*) Muscle power can only be maintained or increased by contraction, and in these exercises the working muscles are strengthened and hypertrophied in response to the tension created in them by the resistance. Their power and endurance is increased.

Resisted exercises are used to build up weak muscles and so to restore the balance of muscle power which is essential for stability and co-ordinated movement. When all the muscles are weak, power and function are improved.

(*ii*) The blood flow to the working muscles is increased in proportion to the amount of work they are called upon to do thus providing the materials for repair and hypertrophy.

Although the flow is impeded during the actual contraction, the amount of blood contained in the muscles immediately after contraction may be as much as ten times as great during strenuous exercise as the amount contained during rest.

This increase in the blood flow to the muscles continues for some time after exercise, bringing oxygen and nutrition to the part and assisting the removal of metabolic products.

(*iii*) A general rise in blood pressure frequently anticipates exercise and may be increased by the mental effort required to perform these exercises correctly.

(*iv*) Heat, which is produced as the result of strenuous muscular activity, stimulates the heat-regulating centre causing vaso-dilatation in the skin. This follows a constriction of these vessels which occurs in the first place to compensate for the increase in the blood flow to the muscles. If there has been sufficient exercise, the skin feels warm and possibly moist and appears pink, indicating that heat is being lost from the surface to balance the gain from muscle activity and so keep the body temperature within normal limits. The degree of moisture depends largely on the temperature, humidity and movement of the atmosphere.

ACTIVE EXERCISE

(*Involuntary Movement*)

a. Reflex Movement

Reflex movements, which are always involuntary, occur in response to sensory stimulation, which is transferred to the muscles without the knowledge of the cerebral cortex, as the co-ordinating centre is situated

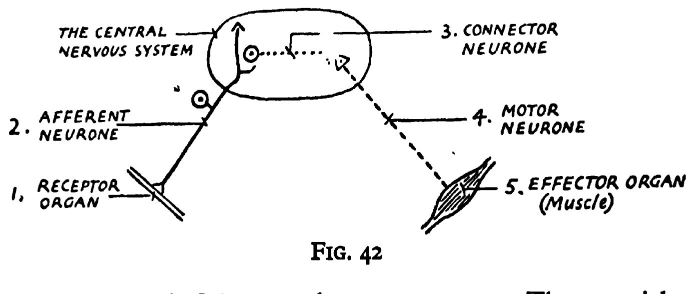


Fig. 42

at some lower level of the central nervous system. The essential constituents of the pathway by which the impulses travel are theoretically, in the simplest form, as shown in Fig. 42.

Knowledge of the movement only reaches consciousness after the muscular contraction has been initiated.

Flexor Reflexes

Reflexes which arise from painful stimuli are mostly flexor in character, their purpose being to protect the body from harm, e.g. the withdrawal of a hand on touching a hot iron, or of a foot on stepping on a nail.

Extensor Reflexes

These are weaker than the flexor reflexes, and easily give way to them if pain is experienced. They are most easily demonstrated in the leg, where they involve the use of the anti-gravity muscles and are elicited by firm pressure on the foot when the leg is bent.

The Myotatic or Stretch Reflex

This reflex is also protective in character and is demonstrated by a sudden and usually unexpected stretch on a muscle or its tendon, e.g. the knee jerk. This contraction, which results from the stretching of a muscle, is a device to protect it and the underlying tissues from injury. Many instances of this contraction, which occurs in response to passive stretching, are met in the application of exercise therapy. It may be a response to be encouraged or to be avoided, according to the circumstances.

Conditioned Reflexes

This type of reflex is not inborn, but is developed with the co-operation of the cerebral cortex. A particular response to a particular stimulus may be initiated by the cerebral cortex so often that it eventually becomes unconscious or habitual. Examples of this are the ability to walk or to ride a bicycle, which are both activities which were achieved with much conscious effort, but once learnt become conditioned reflexes requiring no conscious effort. Thus the higher centres are set free to concentrate on other things, such as the traffic or the scenery.

The Postural Reflex

This is an extremely complicated series of reflexes, some of which are inborn and some conditioned (see Chapter 15, 'Posture', p. 246).

In the healthy body reflexes always run true to form, although many can be inhibited voluntarily, if the higher centres are informed in time. Failure to elicit a response, or an alteration in the nature of the response, to a given stimulus is of diagnostic significance in some diseases.

b. Associated Movements

A movement which occurs involuntarily and accompanies another movement which is usually voluntary may be called an associated movement. These movements probably arise as the result of spreading of the impulses discharged to promote the initial movement.

Examples

(*i*) Stimulation of the involuntary musculature of the alimentary tract is associated with that of the voluntary musculature of the abdominal wall.

(*ii*) The muscles of the pelvic floor may contract when the Hip Extensors and Adductors are strongly innervated.

(*iii*) Muscle groups which habitually work together tend to contract when one of their number is thrown into action. The association in this case is usually of fixator or synergic origin.

(*iv*) Corresponding muscles on the opposite side of the body tend to contract in unison, or reciprocally, when those of one side are stimulated, as in the case of muscles on either side of the face or of the muscles of the legs used in walking.

(*v*) Intense concentration on the performance of one movement may lead to the production of an apparently useless movement such as biting the lips or frowning.

(*vi*) Pathologically, movements such as those of tremor frequently accompany specific voluntary movements.

In some cases association between movements can be utilised, as for instance in obtaining contraction of the muscles of the pelvic floor, and exercises in which both limbs are involved are frequently beneficial when the function of one is impaired.

PART II

5

RELAXATION

MUSCLES which are relatively free from tension and at rest are said to be relaxed. Tension develops in muscles as they work during contraction and this tension is reduced to a variable degree as the muscles come to rest during relaxation.

Muscle Tone

Under ordinary circumstances living muscles are never completely free from tension, as they retain a quality of firmness known as muscle tone even when they are as relaxed as possible.

Muscle tone, which represents a state of preparedness in resting muscles, is now thought to be maintained through the activity of the muscle spindle circuit. The efferent fibres of this small fibre nervous reflex pathway transmit impulses which produce a sustained contraction of the small intrafusal muscle fibres of the muscle spindles, while the large extrafusal fibres concerned in the production of voluntary movement remain relaxed.

Postural Tone

The contraction which persists in the muscles concerned with the maintenance of posture (chiefly the anti-gravity muscles) is called postural tone. Postural tone is maintained and regulated by a reflex mechanism, the fundamental basis of which is the myotatic or stretch reflex, although the higher centres also exert a controlling influence. Any stretching of the muscles by an external force, such as the force of gravity, stimulates sensory receptors situated within the muscles themselves and so gives rise to a discharge of motor impulses to the same muscles. These motor impulses bring about a contraction of a sufficient number of the muscles' motor units to increase the tension sufficiently to enable the effects of the force which produced the stretching to be counterbalanced.

As tension in these muscles is increased in response to stretching of their constituent fibres by an external force, and in proportion to the degree of stretching to which they are subjected, it follows that the use of measures tending to reduce or eliminate the effect of this force assists in promoting their relaxation.

The degree and location of postural tone varies with any alteration in posture. It is greater in the upright positions, *in which the force of gravity tends to stretch the muscles more strongly, than it is in* recumbent positions, in which the effects of the force of gravity upon them is adequately counterbalanced by full support of the body. Those recumbent positions which provide full support for all segments of the body are therefore most suitable for obtaining general relaxation

Voluntary Movement

Specific muscles contract as they work to initiate or control movement, but at the completion of the movement in question they relax and come to rest. Contraction in any one group of muscles is accompanied by a reciprocal relaxation of the antagonistic group to allow movement to take place smoothly. This fact is of importance during consideration of methods designed to obtain relaxation of a particular group of muscles.

Mental Attitudes

Mental attitudes such as fear, anger and excitement give rise to a general increase in muscular tension which serves a useful purpose by preparing the muscles for rapid or forceful action.

Normally this tension, developed to serve a useful purpose, is relaxed when the need for it no longer exists, but in some cases it persists and becomes habitual.

Recognition of a state of tension followed by voluntary relaxation of the muscles in which it is present provide a means of helping the patient to economise in nervous energy, and in cases where the tension has resulted in the reduction of the normal range of movement in a joint, an increase in mobility can be achieved.

As fear in one form or another is the most usual cause of persistent tension, the physiotherapist must do her best to reassure the patient and to gain his confidence and co-operation. An atmosphere conducive to rest, both mental and physical, contributes much to success in helping the patient to acquire the art of voluntary relaxation.

Degrees of Relaxation

The degree to which muscular tension can be reduced is very variable and it is better to regard the term 'Relaxation' merely as an indication that some reduction in tension has taken place. It is often possible to estimate the degree of relaxation achieved by palpating the muscles, as for instance during massage, and the fact that a patient falls to sleep during treatment is ample proof that the method of obtaining general relaxation has been successful.

Pathological Tension in Muscles

A marked, persistent increase in muscular tension or tone is a feature of many pathological conditions which affect the nervous system. Lesions of the higher motor centres, and those which interfere with the normal function of the nervous pathways which connect them with the spinal reflex arc, commonly result in an abnormal state of muscular tension which varies from hypertonicity to spasticity or *rigidity. A temporary reduction in this tension in the affected area* can be achieved in some cases by suitable means which promote relaxation, and this allows re-education of any functional activity which remains to take place.

TECHNIQUE

1. General Relaxation

Support, comfort and a restful atmosphere are basic conditions for general relaxation and may prove effective without additional methods.

a. *Support*

Various forms and modifications of the *lying* position are used, to achieve full support of the body, the relative suitability of each one varying according to the condition of the patient and to individual preference. The weight of the body is thus effectively counterbalanced by the uniform upward pressure of a reciprocal surface, or by suspension, in a position of semi-flexion which obviates all mechanical tension on muscles or ligaments.

(*i*) *Lying Supine.* A firm surface is essential, and if resilient also, as in the case of a good spring mattress, it is ideal, as it will mould itself to the body contours and give even pressure and comfort. At all costs plinths or beds which sag are to be avoided as they cramp the thorax and so throw additional strain on the inspiratory muscles. A head pillow is required which is sufficiently soft to prevent the head from rolling to either side, and to be well moulded to support the neck posteriorly. A small pillow under the knees relieves tension on the Hamstrings and the ilio-femoral ligament, and consequently allows the pelvis to roll backwards so that the lumbar spine is straightened and supported. The feet are held in the mid-position by a sandbag or similar device, and each arm, slightly abducted at the shoulder and flexed at the elbow, rests on a pillow.

Fig. 43. *lying supine* for Relaxation

(*ii*) *Half Lying.* This is similar to the previous position but breathing is easier as there is less weight on the back and abdominal pressure on the under surface of the Diaphragm is reduced.

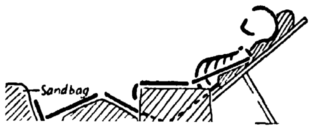


FIG. 44. *half lying* adapted for Relaxation

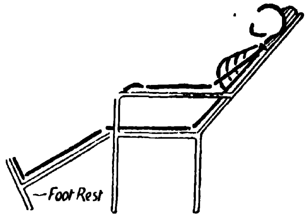


FIG. 45. *half lying*. Another method

An armchair makes quite a good substitute for a plinth or bed, the thighs are fully supported and the feet rest on the floor, or a footstool, or a T-shaped footrest.

(*iii*) *Total Suspension.* Each unit of the body is suspended by a suitable sling placed under the centre of gravity of the part, and attached by a vertical rope to a strong overhead support. The arms

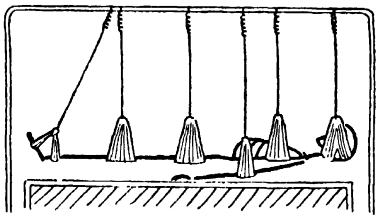


FIG. 46. *lying*. Total suspension in slings

are abducted slightly with the forearms pronated and the feet are held in the mid-position by a supporting sling and rope. The inclusion of tension springs gives additional comfort and a feeling of buoyancy as they stretch and recoil with the respiratory movements.

(*iv*) *Prone Lying.* The head is turned to one side and may rest on a small pillow, if more comfortable. A firm pillow under the hips and the lower abdomen prevents hollowing of the back, and for women it should extend higher to avoid too much pressure on the breasts; the

FIG. 47. *prone lying* as for Relaxation

lower leg is elevated so that the knees are slightly bent and the toes free. A degree of medial rotation at the hips, causing the heels to fall apart, still further induces relaxation of the legs. Many find this position comfortable and use it for sleeping; others dislike it because of the rotated position of the head.

(*v*) *Side Lying.* The measure of relaxation obtained is governed by the efficiency with which the shoulder and pelvic girdles are stabilised. The arm and leg which are uppermost may be rested on the supporting surface instead of on pillows, but some of the weight then falls on the

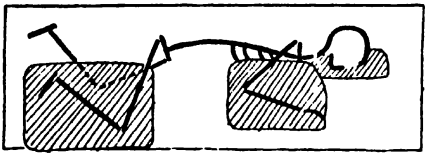


FIG. 48. *side lying* for Relaxation (view from above)

trunk and this impedes respiration. The head pillow supports the neck and head in alignment with the body, and must not be too high. The majority of people sleep on the side, but few are conscious of the part suitable positioning for relaxation plays in promoting it.

b. *Comfort*

In addition to support and individual preference in positioning, for which some suggestions have already been made, the ingredients of comfort include freedom to breathe deeply, warmth, abdominal quiescence and a mild degree of physical fatigue. Removal of constrictive clothing, such as corsets and belts, is essential and any garters, buttons or suspenders liable to cause pressure must be removed. The room should be warm, but should have a free supply of fresh air; in winter additional warmth can be supplied by light but warm blankets, a covered hot-water bottle at the feet, an electric blanket or by non-luminous infra-red irradiation, but care being taken to avoid over-heating, as this leads to restlessness. For home use a warm bath gives the most even and pleasing type of heat, but its soothing effect must not be ruined subsequently by vigorous rubbing with a towel. A light well-balanced meal, rhythmical physical activity of short duration, such as a brisk walk in the open air, and attention to emptying the bladder before treatment are all conducive to general relaxation.

c. *Restful Atmosphere*

As physical and mental relaxation are interdependent, an effort must be made to secure a state of mental rest. The treatment-room should be as quiet as possible, as many people for whom training in relaxation is prescribed are highly susceptible to the disturbing influence of noise. A few are worried by complete silence, but in general it is the high-pitched intermittent sound produced close at hand which is to be avoided; the continuous low-pitched 'hum' of distant traffic tends to be soothing. Bright lights and strong colours, such as red and bright yellow, are said to be stimulating, whereas a room with low well-diffused light with for instance green and peach furnishings gives a soft and warm glow and provides an ideal setting for relaxation. This is indeed a counsel of perfection, but much can be done with screens and shades used with a little imagination, even in a busy department!

The most difficult and important factor in the creation of a restful atmosphere, and one which determines the ultimate success or failure of the treatment, is the manner and bearing of the physiotherapist. She must inspire confidence, as fear, in one form or another, is at the root of much of the tension which she can help to relieve. Her appearance must be tidy and her dress suitable; she must be punctual and move calmly without hurry or hesitation. Her manner must be courteous, pleasant and understanding and her voice low-pitched and clear. A simple explanation of the routine and any instructions required are given to the patient in language and terms which he can understand, so that any anxiety or fear of the unknown is removed. It must be remembered that situations and routines with which one becomes very familiar often appear strange and terrifying when encountered for the first time. Conversation, apart from these instructions, should direct the patient's thoughts to contemplation of restful and pleasant topics.

Confidence in the physiotherapist and the treatment is gradually built up over a period of time; immediate results are not to be expected and are rarely achieved, often because of psychological factors beyond the control of the physiotherapist or patient. In successful cases a habit of relaxation is built up in place of a habit of tension, but the formation of new habits takes time. Regular and frequent practice on the part of the patient is essential, until finally he becomes an expert in the art of 'letting go' or relaxing, and the normal rhythm of life, in which activity alternates with relaxation, can be re-established.

d. *Additional Methods of promoting Relaxation*

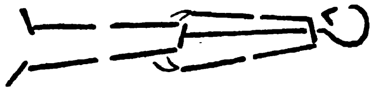
Tension may persist in spite of the provision of conditions conducive to relaxation, in which case additional methods to help the patient may be employed. Very little should be attempted at first, the period of time being extended as the ability to relax improves.

Consciousness of Breathing. Under conditions of quiet and comfort the patient's mind may remain active and turn to mundane problems and anxieties, with associated physical tension; in this case it may help him to concentrate on his own rhythm of breathing, which must be deep with a slight pause at the end of expiration. Expiration is a phase of relaxation and should be accompanied by a feeling of 'letting go' in the whole body.

Progressive Relaxation. A method by which relaxation may be achieved progressively was devised and practised by Jacobson of

Chicago, and something similar appears in modern literature on the Yoga System as the 'Savasana' or 'Still Pose'.

FIG. 49.
'Savasana'—'The Still Pose'



Difficulty in appreciating the sensation of relaxation is not uncommon; the patient does not know that the muscles are tense or what to do in order to relax them. This can often be taught by demonstrating the contrast between maximal contraction and the degree of relaxation which follows it, the patient being told to contract any group or series of muscles as strongly as possible and then to 'let go' and 'continue to let go'. Success may be achieved by another method by which the patient is urged to step up this preliminary contraction until he is so tired that he has to let go; there is a large element of suggestion about this as it is unlikely and undesirable that a state of fatigue should actually be produced. This method follows the biological principle that activity of living cells tends to be followed by inhibition of that activity.

Routine contraction followed by relaxation is carried out in each area of the body, the attention travelling in logical sequence from limb to limb and to the trunk and head including the neck and face muscles until all areas can remain relaxed at one and the same time. Much practice may be necessary before this is accomplished, and it is not unusual for the muscles of the leg, for instance, to again become tense while attention has been focused on relaxation of the face muscles. Before the routine has been completed, the patient frequently drops off to sleep and general relaxation is obtained. When possible he should be allowed to wake naturally; alternatively, he must be wakened gently in sufficient time for getting up and dressing to be unhurried. Later, the patient learns to relax the muscles at will from the state of tension in which they are normally maintained, and without previous voluntary contraction.

Passive Movement. Rhythmical passive movements of the limbs and head may assist the degree of general relaxation in some cases. These movements are generally given as a sequel to massage. Group movements of joints, e.g. flexion and extension of hip, knee and ankle, are preferable, but a very high standard of performance on the part of the physiotherapist is required to obtain results. In total suspension, the rhythm of small pendular movements pleases some patients.

The ability to promote a state of relaxation depends very largely on the individual physiotherapist and the particular patient with whom she is dealing, and details of successful methods employed vary widely

Ideal conditions are rarely obtainable and, indeed, are hardly desirable, for many patients must eventually learn to relax where and when the opportunity presents itself, e.g. in the train or on a mountain top after a strenuous climb. General relaxation can sometimes be carried out effectively in groups, as in the case of pregnant women, who tend to relax easily, and with some asthmatic and bronchitic sufferers who have had previous individual instruction.

2. Local Relaxation

General relaxation takes time and is not always essential or desirable. Methods of obtaining local relaxation depend to some extent on the cause and distribution of the tension, although the general principles of support and positioning, comfort and confidence, all play a part.

Preparatory to Massage and Passive Movement

Massage and passive movement both presuppose relaxation of the area under treatment. Relaxation can be localised to a specific area by the application to that area of the general principles already described for the whole body. A general attitude of rest, however, will assist the process, e.g. the abducted and flexed arm supported by a table or slings is more inclined to relax when the patient lies or reclines in a chair, than when he sits bolt upright.

For the Relief of Spasm

Spasm due to pain is protective and is most effectively relieved by the removal of the pain which causes it. If, however, it is due to fear of pain on movement, rhythmical assisted or pendular movements, starting in small range and gradually increasing, will often restore confidence and assist relaxation.

The relief of pathological spasm caused by lesions of the upper motor neurones and the higher motor centres is only temporary but it may be sufficient to allow a measure of voluntary control to be established, and to prevent contractures. Rhythmical passive movements with smooth but firm and steady traction on the most spastic groups, following, or combined with, massage performed in a centrifugal direction, are often successful in combination with conditions conducive to general relaxation. An attempted contraction against resistance of the muscles antagonistic to a specific group may also encourage reciprocal relaxation of the latter.

In preventing and combating Adaptive Shortening

Persistent tension or hypertonicity of muscles acting upon one aspect of a joint produces a state of muscular imbalance which leads to adaptive shortening of the tense muscles and progressive lengthening and weakening of the antagonists on the opposing aspect of the joint.

Techniques which help the patient to recognise tension in a particular muscle group, and to relax them voluntarily, assist the restoration of muscular balance and prevent adaptive shortening. To combat adaptive shortening which has already developed in a particular muscle group, the use of suitable positions which produce a measure of traction on this group *combined with* strong innervation of the antagonistic group to secure reciprocal relaxation, may succeed in stretching the shortened muscles without eliciting the normal reaction of contraction brought about by means of the myotatic reflex.

PART III

6

JOINT MOBILITY

SKELETAL mobility occurs at the joints, the type and range of movement possible depending on the precise anatomical structure of the joint and the efficiency of the muscles controlling it.

The slightly movable or secondary cartilaginous joints all lie in the median plane and permit a limited degree of movement by compression of a fibrocartilaginous disc interposed between the bony surfaces, e.g. the pubic symphysis and joints of the vertebral bodies.

The freely movable or synovial joints predominate in the body and, with one exception, include all the joints of the limbs.

Structural Features

The adjacent areas of bone are covered with hyaline articular cartilage, which is smooth and resilient and reduces friction. The ligaments of white fibrous tissue are flexible and pliant and offer no resistance to the normal range of movement, but are inelastic and unyielding to prevent excessive or abnormal movement. Excessive stretching of this tissue stimulates the sensory receptors with which it is freely supplied, and causes pain and spasm in the muscles antagonistic to the force responsible for the stretching. The capsular ligament completely encloses the joint and supports the synovial membrane which secretes synovial fluid to lubricate the joint cavity and, in all probability, to nourish the cartilage. Ligaments of the joint, consisting of localised thickenings of fibrous tissue, re-enforce the capsule, and accessory ligaments, which may be extra- or intra-capsular and stand clear of it, give additional strength. Tendons or fibrous expansions of muscles sometimes function in the capacity of ligaments. In some joints fibrocartilaginous structures and pads of fat are interposed to make the articular surfaces more congruent, or to act as buffers. They are usually adherent to the capsule at their circumference and are enveloped by the synovial membrane. Sensory stimuli from the joint record pain, pressure and the knowledge of position in space and are carried in the nerves which supply the muscles working over the joint. Nutrition is received from the blood vessels in the vicinity. Joints are stabilised by the balanced contraction of muscles, and are activated by the co-ordinated working of opposing groups. They can also be moved passively by an outside force when the muscles are relaxed.

Classification

Joints may be classified according to the movement they permit.

Uni-axial. Movement takes place about one axis: in a hinge joint it is flexion and extension (e.g. knee), in a pivot joint it is rotatory (e.g. atlanto-axial).

Bi-axial. Movement takes place about two axes: a condyloid joint allows the four angular movements, flexion, extension, abduction and adduction, and a combination of these four called circumduction (e.g. wrist), and a saddle joint such as the carpo-metacarpal joint of the thumb is similar.

Poly-axial. Movements about many axes occur in ball and socket joints: they are the four angular movements, circumduction and rotation (e.g. hip).

Plane. Small gliding movements only are allowed, probably being more or less poly-axial in character (e.g. acromio-clavicular).

Some joints permit small accessory movements in certain positions which cannot be performed voluntarily.

Under normal conditions joint movements are usually limited by tension of the opposing muscles, contact of soft tissues or tension of ligaments. For example, abduction of the hip is limited by the tension of the Adductor Muscles, flexion of the hip with the knee bent is limited by contact of the thigh with the abdomen, and extension is limited by the tension of the Flexor Muscles and the ilio-femoral ligament. The active range is usually greater than the passive range of movement owing to the reciprocal relaxation of the antagonistic group of muscles.

Limitation of the Range of Joint Movement

Injury or disease may attack each or all of the structural components of a joint and lead to a reduction in the normal range of movement. The factors which commonly cause limitation are:—

(*i*) Tightness of skin, superficial fascia or scar tissue. This limits both the active and passive range.

(*ii*) Muscular weakness or inefficiency. Weakness or flaccidity of muscles limits active range if the power of the muscles is insufficient to overcome the resistance offered by the weight of the part moved. Spasticity of muscles limits or prevents both active or passive movement, as the muscles antagonistic to the movement are unable to relax and allow it to take place.

(*iii*) The formation of adhesions. These limit both active and passive movement. Adhesion formation occurs following the output of a sero-fibrinous exudate into the region of the joint or into the joint itself. The joint structures become soaked in this exudate and if it is not speedily removed the fibrinous constituents of the exudate 'glue' the collaginous fibres of the ligaments and tendons together. The fibrinous 'glue' constitutes the adhesion, which is relatively soft at first and easily broken, but later, when the adhesions are consolidated, they contract to form scars. In this way the limitation of movement may be progressive. In the case of the shoulder joint, for example, adhesion formation may limit movement considerably, the capsule being 'glued' in folds, if the joint is allowed to remain in the same position for too long.

(*iv*) Displacement or tearing of an intracapsular fibrocartilage or the presence of a foreign body in the joint. Limitation of both passive and active movement may be present in this case, when either are accompanied by intense pain as the result of which the joint becomes locked by muscular spasm.

(*v*) Cartilaginous or bony destruction. The pain which arises may limit both active or passive movement and the articular surfaces will not slide easily upon one another. Bony or fibrous ankylosis limits movement altogether. Bony obstruction, such as in myositis ossificans, limits range in the direction of the obstruction.

(*vi*) Sometimes no organic cause can be found when the patient is unable to move a joint.

The Prevention of Joint Stiffness

Whenever possible it is the physiotherapist's duty to prevent a joint from stiffening, and thereby save the patient pain and the possibility of a permanent disability. The period of rehabilitation can be considerably reduced in many cases and a return to work made possible. The motto that 'Prevention is better than cure' was never more apt than when applied to stiff joints.

Methods of prevention vary to some extent with the cause of the potential stiffness. Tightness of skin, fascia and scars must be combated by hot pack, soaking or massage. Muscles must be exercised by contraction to maintain their efficiency; if the joint can be moved this is easy, if not, static contractions must be performed frequently and to their fullest extent. 'Five minutes in every hour' is the slogan. Coarse muscles, such as the Quadriceps, Glutei, Deltoid and Gastrocnemius, waste very rapidly and only build up comparatively slowly. In cases of flaccid paralysis or paresis, passive movement of the joint within its full physiological limits must be performed twice a day, two full-range movements being sufficient. Where muscular disbalance is present, strengthening of the weakened antagonists is urgent, or if this is impossible, or slow, the latter must receive the assistance of a support or splintage. An effort is made to relax spastic muscles by whatever means appears to be applicable. (See Relaxation.)

Myositis ossificans is unlikely to occur if the method of mobilisation used in the early stages after traumatic injuries is by *free active movement only*. Memory of the pattern of movement must be retained by sensory stimulation provided by passive movement when active exercise is impossible.

The formation of adhesions in the collaginous tissues of tendons, ligaments and fascia must be prevented by attempting to control the output of the sero-fibrinous exudate and by measures to expedite its removal. Firm bandages, cold packs or cooling lotions, chemotherapy and rest, reduce the output to the minimum during the acute stage by removing the cause of the exudation or by reducing the circulation in the area. The position of rest is of some importance, as it is designed to ensure an equal degree of tension on all fibres of the capsule. If a portion of the capsule is slack and prone to fall into folds, adhesions form very readily and glue these folds into tucks, therefore the knee joint is rested for example in 20 degrees of flexion and the shoulder joint is partially abducted.

Except in cases of bacterial infection, persistent effort must be made to assist the removal of the exudate or swelling before adhesions become organised, even if the affected joint has to be rested for a time to prevent further exudation. Elevation of the part, elastic bandaging and rhythmical active exercise of muscles and joints in the vicinity assist the venous return and ensure the free movement of tendons passing over the affected joint. Other methods of improving the circulation, such as contrast baths, massage and heat, may also be employed if required. Careful active movements of the affected joint are begun as soon as possible and should progress rapidly. These movements maintain the power of the working muscles, ensure the freedom of tendons, and enable the pattern of movement to be remembered. Passive movements can also be used but they are more likely to give rise to minor trauma of the affected joint with consequent further output of exudation, and their effect on the circulation is minimal.

Mobilising Methods

Limitation of the range of movement impairs the function of a joint and the muscles that move it. Measures which increase the range of movement must, therefore, go hand in hand with those which build up sufficient muscle power to stabilise and control that movement. As instability and lack of control lead directly to further injury, it is absolutely essential to ensure that every degree of mobility gained can be controlled by muscular action. Active exercise, which leads to an increase in range, works the muscles and reminds the patient of the pattern of movement, is the treatment of choice; in some cases, however, relaxation and passive or manipulative methods precede or assist its performance.

1. *Relaxation*

Where spasm causes limitation of movement relaxation leads to an increase in range.

2. *Passive Movement*

(*i*) Relaxed Passive Movement maintains but does not increase mobility. It is used when active exercise in the same range is impossible or contra-indicated.

(*ii*) Forced or Manipulative Passive Movement increases mobility, and active exercises which follow maintain this increase.

(*iii*) Manipulations. It is an advantage for the physiotherapist to watch the surgeon manipulate so that she sees the range of movement to be maintained, and can treat the patient as soon as possible after he comes round from the anaesthetic. Accurate recording and the earliest possible treatment to assist and check the patient's home exercises are the only satisfactory alternative.

3. *Active Exercise*

Assisted Exercise. Rhythmical movement, in which muscular contraction and assistance combine at the limit of the free range against the resistance of the limiting structures, is often successful in increasing the range. The patient's co-operation and strict supervision by the physiotherapist are essential to achieve results.

Free Exercise. This is a most valuable method as the exercises can be learnt and carried out at frequent intervals by a co-operative patient. This co-operation, and accurate instruction to ensure the correct movement, are essential. Pendular movement is used with an attempt to increase the amplitude, or a series of contractions or 'pressing movements' are performed at the limit of the range. Circulation is also increased.

Resisted Exercise. Strengthening of all the muscles passing over a stiff joint by means of resisted exercise is, in many cases, the most effective means of increasing the range. The muscles must be exercised in the pain-free range or position, preferably with traction maintained throughout the movement. Should there be spasm in the muscles antagonistic to the movement, reciprocal relaxation of these muscles may be promoted by encouraging strong contraction of the agonists.

Objective, Occupational and Diversional Activities such as ball exercises, scrubbing and hiking may fall into any one of the three previous categories. They interest the patient, increase the circulation and the variety of natural movement may help to 'shake loose' joints which do not respond to other methods; in any case they are always a valuable adjunct to more localised treatment.

7
TECHNIQUE OF MOBILISING JOINTS

THE aim of mobilisation may be either to maintain the present range of movement in a joint or to increase it. Relaxation, Relaxed Passive Movements, Forced Passive Movements, Manipulations, Assisted Exercises, Free Exercises, Resisted Exercises or General Activities all have a part to play in the mobilisation of joints in one case or another. The technique of Relaxation has already been considered, Manipulations under an anaesthetic are the province of the doctor or surgeon and the technique of Resisted Exercises is described in a subsequent chapter, so none of these will be considered here. With regard to all Free Exercises it is important to emphasise that a mobilising effect results not so much from the choice of a particular exercise but depends very largely on the manner in which it is performed. Full-range movement at natural speed with emphasis at the limit of the range and repeated many times and at frequent intervals seems to be most effective, but sometimes a more rapid movement or a sustained contraction are also used.

Measurement

Some method of measuring the range of movement achieved is required to assess progress, and for record purposes. Accurate measurement is very difficult to achieve by any of the methods in common use, but the margin of error is reduced when the same method is used on each occasion for a particular patient and when it is carried out by the same physiotherapist under the same conditions and at regular intervals.

The angle at a joint can be measured with the use of a hinged ruler and a protractor or, in the case of the pelvic tilt, with a pelvic inclinometer. Other methods include assessment of the arc of movement, carried out with the part moved supported on a flat surface, and measurement with a tape measure between two bony points. A guide to the range of movement possible in the thoracic cage is gained by comparison of the measurements of the circumference of the thorax at a specific level, during maximum inspiration and maximum expiration; alternatively, measurement of the vital capacity can be made with the use of a spirometer.

JOINTS OF THE FOOT

The many joints of the foot all contribute to its ability to adapt itself for walking on uneven surfaces, and to its resilience. With the exception of the transverse tarsal and subtaloid joints the range of movement at the intertarsal, tarsometatarsal and intermetatarsal joints is very small and cannot be localised to a single joint.

Relaxed Passive Movements of the Foot

Interphalangeal Joints of the Toes

Each of these joints can be moved separately with the patient *sitting* or *lying* with the foot relaxed. The bone proximal to the joint moved is fixed, traction is given in the long axis of the joint and the full free range of flexion and extension is performed with a slight pause for overpressure at the end of each movement. Extension usually requires emphasis, as curling of the toes frequently limits this movement.

Metatarsophalangeal Joints of the Toes

½ ly.; Toe flex. ext. abd. add. and ʘ (pass.)

Passive movements of each joint may be done separately or all five joints may be moved simultaneously, in which case the fingers of the physiotherapist's fixing hand lie under the arching shafts of the metatarsal bones and her thumb rests on the dorsum of the foot. Her other hand grasps the proximal phalanges, gives traction and then performs the movement. Alternatively the distal phalanges may be grasped, and, while the toes are kept straight by traction, the movements are performed at the metatarsophalangeal joints, usually with emphasis on flexion. This alternative method is preferable as it more nearly approaches the correct functional movement of the toes in gripping the floor. For abduction and adduction all the toes are moved together either medially with regard to the body, or laterally. The great toe may need special attention. Some accessory rotation, side to side, and antero-posterior gliding movements are also possible when the joints are distracted.

Intermetatarsal Joints of the Foot

These movements cannot be performed actively except in conjunction with other movements. Small up and down movements between the distal ends of the bones performed passively help to keep the foot resilient. Upward pressure of the physiotherapist's fingers bunched behind the heads of the metatarsal bones on the sole of the foot, in combination with a stroking movement performed with her thumbs on the dorsum,

Fig. 50

moulds the anterior transverse arch of the foot into what should be its normal non-weight-bearing position (Fig. 50).

Intertarsal Joints of the Foot

Movement takes place between all the tarsal bones, but the range is small except in the transverse tarsal and subtaloid joints.

(*i*) *The Transverse Tarsal Joints*

½ *ly.; 1F. inv. and ev. (pass.)*

One of the physiotherapist's hands fixes the patient's ankle in dorsiflexion to prevent the lateral movement which may take place in this joint during plantaflexion. The other hand grasps round the distal row of the tarsus and the bases of the metatarsal bones from the lateral border of the foot and then inverts and everts the forefoot. Traction and overpressure are given in the usual way.

(*ii*) *The Subtaloid Joint*

Movement here usually accompanies inversion and eversion so that the heel falls in the same plane as the forefoot. With the leg resting horizontally the heel is grasped with both hands, as in a clamp, and while traction is maintained on the tendo-calcanaeum a side-to-side gliding movement on a vertical axis is performed. Fixation of the talus by means of pressure on the lateral malleolus with the fingers, and on the medial aspect of the talus with the thumb, while the calcanaeum is moved on it by the other hand, is another method which may be used.

Ankle Joint

crk. ½ *ly.; 1Ank. dorsifle. and plantaflex. (pass.)*

Tension on the Calf Muscles must be slackened to avoid limitation of dorsiflexion, therefore some position in which the knee is bent must be selected. *Half lying* with the patient's knee bent over a firm pillow or across the physiotherapist's knee, leaving the heel unsupported, is a suitable starting position. The physiotherapist's fixing hand grasps immediately above the joint while her other hand grasps round the foot at the level of the tarsal joints to perform the movement. Overpressure during dorsiflexion may be given with this hand in the same position or by means of traction on the heel with the forearm on the sole of the foot. The plantar structures must not be strained by pressure on the forefoot.

Forced Passive Movements of the Foot

Interphalangeal Joints of the Toes

Sustained traction on these joints to straighten the toes stretches the tightened structures on their plantar aspects which produce curling of the toes. When a single toe is affected it may be strapped to adjacent toes to maintain correction.

Metatarsophalangeal Joints

The foot is grasped as for the relaxed passive movements, the ankle joint being fully dorsiflexed. The movements are performed with continued traction and firm overpressure.

Intermetatarsal Joints

These are similar to the relaxed passive movements but an effort is made to increase the range by using staccato movements.

Intertarsal Joints

(*i*) *The Transverse Tarsal Joint*

The physiotherapist sits astride and supports the patient's leg, which must be straight, across one knee. She grasps the foot firmly with both hands and the movement is forced as she rotates her trunk to alternate sides (Fig. 51).

(*ii*) *The Subtaloid Joint*

The grasp and performance of the movement is similar to that used for the relaxed movements but the movement in this case is more forceful.

Ankle Joint

The grasp is the same as that for the transverse tarsal movements but in this case the physiotherapist forces the movement by lateral flexion of her own trunk. An increase in dorsiflexion may be obtained by using the force of the patient's own body weight, in which

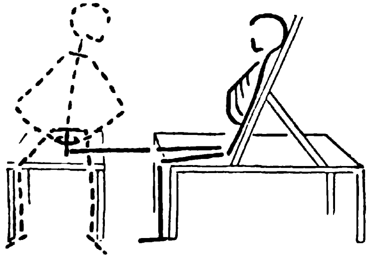


FIG. 51

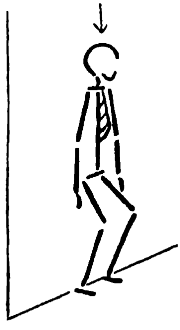


FIG. 52

case he stands back against a wall and bends the knees while the feet are kept flat on the floor (Fig. 52).

Specialised forced passive stretching of tightened structures is required for deformities such as talipes equino-varus. For this condition the baby's knee is bent and protected by the mother while the ankle and heel are grasped so that the physiotherapist's thumb rests on the talus. Using this as a fulcrum for the movement the forefoot is then drawn into abduction and eversion. When this movement is relatively free it is followed by that of dorsiflexion, during which traction is given on the calcaneum in an attempt to approximate the little toe and the anterior aspect of the tibia.

Assisted Exercises for the Foot

Manual assistance can be given to all the muscle groups which move the joints of the foot by using the same grasps as those used for giving passive movements of the joints.

Self-assistance given by means of a rope and pulley or a treadle machine is most useful for home practice.

Examples of Free Exercises for the Foot

Rhythmical exercises which are performed at a speed which allows time for additional pressure at the limit of the free range are used for group treatment and for home practice. A special effort on every 2nd or 3rd beat provides variety and reduces fatigue.

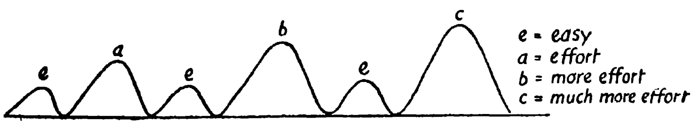


Fig. 53. Effort Pattern for Rhythmical Movement

Exercises during which the foot is free from weight usually precede those in standing.

Non-weight-bearing Exercises

1. For the Ankle Joint

a. *Legs crossed sitting; 1 Foot dorsiflexion and plantaflexion.*

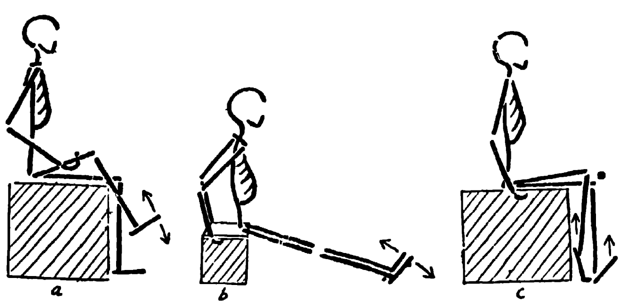


Fig. 54

b. *inclined long sitting; alternate Foot dorsiflexion and plantaflexion* (Treadle Movement) (Fig. 54*b*).
c. *sitting; alternate Heel and Toe raising* (Fig. 54*c*).

2. For the Transverse Tarsal and Subtaloid Joints

d. *Legs crossed sitting (Foot dorsiflexed); Foot inversion and eversion.*

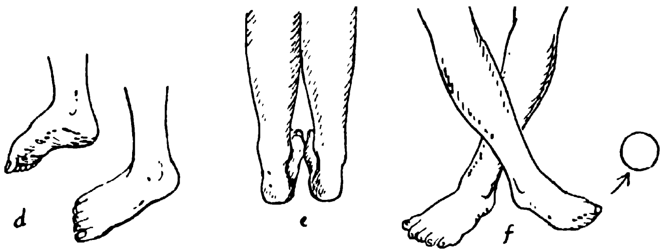


FIG. 55

e. *close sitting; Foot inversion and eversion (inner and outer border raising).*
f. *Ankles crossed sitting; Foot inversion and eversion* (Sweeping Movement).

3. For the Metatarsophalangeal Joints

g. *sitting (Toes resting on book); Toe flexion and extension at these joints, with pressure on balls of Toe.*

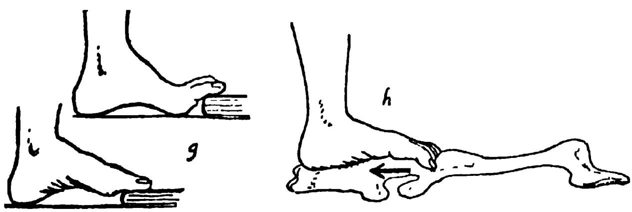


FIG. 56

h. *sitting; Foot shortening by flexion at the metatarsophalangeal joints.* (Draw up stocking under medial longitudinal arch.)
i. *sitting; Toe parting and closing.* (This may be done in water or sand.)

Weight-bearing Exercises

j. *reach grasp high Toe standing (wall bars); Heel raising and lowering.*

k. *reach grasp standing (on rocking board); Foot inversion and eversion.* (See-saw movement of board.)

l. *high standing; walk up inclined form.*

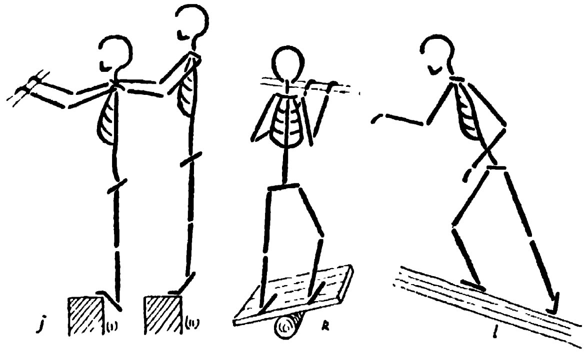


FIG. 57

ACTIVITIES TO INCREASE MOBILITY OF JOINTS OF THE FOOT

Common activities such as walking, running and, later, skipping, dancing and hiking are also good mobilising exercises when the feet are used correctly. Walking and running on uneven ground are specially recommended, as the feet are constantly required to adapt themselves to a varying surface and this requires movement at most or all of the many joints.

THE KNEE JOINT

The joints between the femoral and tibial condyles permit flexion, extension, and rotation in semi-flexion. The latter is possible in this position only when the lateral and medial ligaments, which lie somewhat posterior to the joint, are slackened as the knee is bent. Gliding movements in all directions are possible at the patello-femoral joint when the Quadriceps Femoris is relaxed, and this movement must be free to allow the knee to bend.

RELAXED PASSIVE MOVEMENTS OF THE KNEE JOINT

At the Patello-Femoral Joint

Whenever freedom of movement of the patella cannot be maintained by means of repeated contractions of the Quadriceps Muscles the bone must be moved passively. With the knee fully extended and the muscles relaxed, the patella is grasped between the first finger and thumb of both hands and glided up and down and from side to side.

Between all the Articular Surfaces of the Knee Joint

a. *ly.; 1 Hip and K. flex. and ext. (pass.)*

With the patient in *lying* and relaxed the physiotherapist in *walk* *standing* gives support under the thigh with one hand and with the other hand grasps round the ankle and gives traction. The hip and the knee joints are then moved into full flexion during which the physiotherapist's hand, which is under the thigh, glides to a position in front of the knee to give overpressure at the end of the movement. As the hip and knee are extended, this hand is again moved to its original position to prevent any jarring of the knee at the conclusion of the movement.

b. *s. ly.; 1 Hip and K. flex. and ext. (pass.)*

Either the leg which rests on the plinth or the one which is uppermost may be moved. In the latter case the leg must be fully supported throughout the movement in the hands, in suspension, on a re-education board or in water.

c. *½ crk. ly.; 1 K. rot. (pass.)*

For rotation at the knee the thigh is supported vertically with the knee flexed to a right angle. The physiotherapist supports the thigh with one arm and grasps round the heel with the other hand so that the sole of the foot rests on her forearm, or, she may grasp round the lower leg just above the ankle.

To localise movement to the knee joint either *side lying* or *prone lying* are the most suitable starting positions for the patient.

FORCED PASSIVE MOVEMENTS OF THE KNEE JOINT

Flexion. With the patient in the *half-lying* position his hip is fully flexed and fixed by the pressure of one of the physiotherapist's hands placed in front of the knee. The heel is then forced towards the buttock by grasping above the ankle.

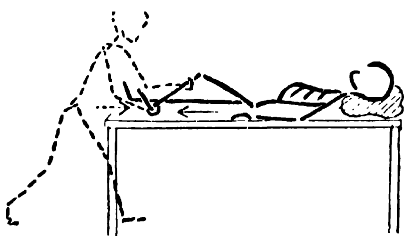


FIG. 58. Knee Extension with Traction

Extension. From the *lying* position the patient's leg is lifted from the plinth with one hand grasping round the back of the ankle, while the other hand, cupped over the knee, gives forceful downward pressure upon it. Extension may also be assisted by traction on the heel and just below the knee (Fig. 58).

Passive Mouldings for Knock Knees. These may be used in treating children up to the age of about four years. The knee is fully extended and one of the physiotherapist's hands fixes the lower leg by pressure on the lateral side just above the ankle, while her other hand gives firm pressure in a lateral direction on the medial condyle of the femur. Inner border raisings on the child's shoes exert a similar and more sustained pressure whenever the child is standing with straight knees.

Assisted Exercise for the Knee Joint

(i) s. ly.; 1 K. flex. and ext. (ass.)

Manual assistance may be given for the Flexors or Extensors of the Knee from *side lying* with the limb supported in the hands or on the surface of a plinth. In the latter case it is convenient to support the other leg in slings, but when the hands are used for support the leg remaining on the plinth is bent up to increase the stability of the trunk. The pattern of movement used should be that of withdrawal of the leg followed by thrust, as in this way the stabilisation of the origins of the muscles working over the knee is adapted progressively to the circumstances of the movement.

During the thrusting movement the physiotherapist's hand is placed under the ball of the great toe in order to gain advantage from the proprioceptive stimulation of pressure on this area. The movement is repeated rhythmically many times and, whenever possible, resistance to the movement is gradually introduced to encourage greater activity on the part of the muscles (Fig. 59).

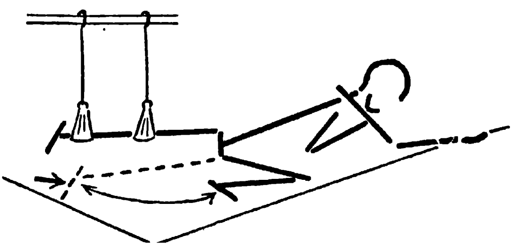


Fig. 59.

(ii) pr. ly.; alt. K. flex. and ext. (auto-ass.)

Auto-assistance can be arranged in the *prone* position, and is particularly suitable when the hip is arthrodesed. A pillow under the pelvis to get a degree of flexion will, however, help the movement if the hip is free.

A rope is attached to the heel of the stiff leg by some suitable device and passed over a pulley on the wall facing the patient, the other end of the rope being attached to the other leg. The rope is

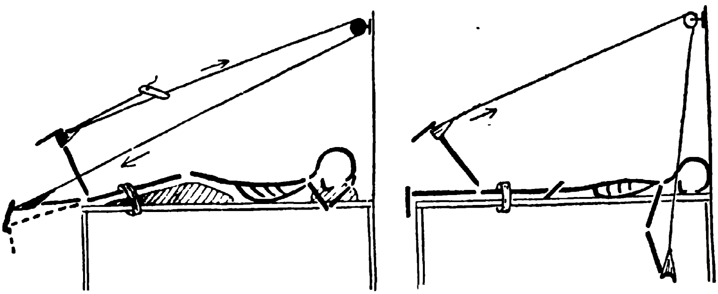


FIG. 60

kept taut throughout by the reciprocal movement of the lower legs, the assisting leg being near full extension when the other reaches the limit of flexion. Alternatively the patient may operate the assistance by hand. Maximum assistance and overpressure are given at the limit of flexion by a right-angled pull on the rope at this point.

Except in special circumstances, these assisted exercises are only of use when movement is very limited or the patient is not allowed to bear weight.

FREE EXERCISES FOR THE KNEE JOINT

These may be non-weight-bearing, partial-weight-bearing or full-weight-bearing according to the condition and the stage of treatment at which they are used. Rhythmical movements with active over-pressure at the limit of the range are essential. In full-weight-bearing exercises, when the body weight is used to assist flexion the power and control of the Extensor Muscles must be sufficient to restore the joint to full extension.

Non-weight-bearing Exercises (Fig. 61)

a. *lying; One Hip and Knee flexion and extension.*
b. *side lying; One Hip and Knee flexion and extension.*
c. *prone lying; alternate Knee flexion and extension.*
d. *high sitting; alternate Knee flexion and extension.*

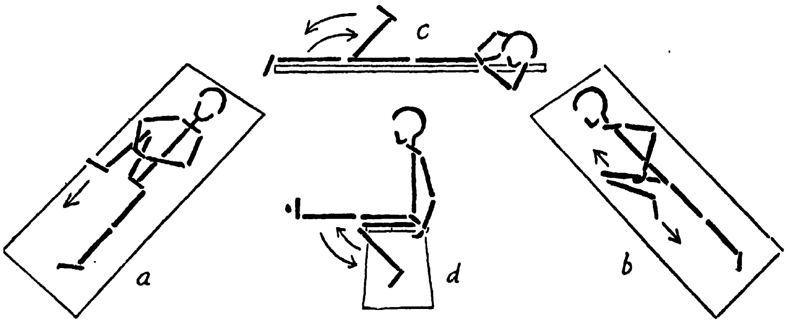


FIG. 61

Partial Weight-bearing Exercises
e. *Bicycling* on free or stationary bicycle.

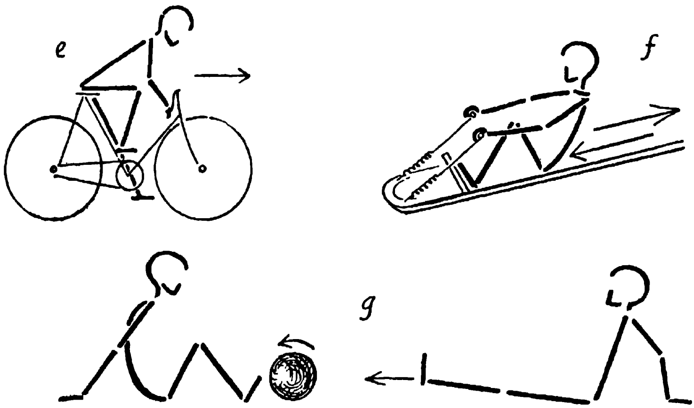


FIG. 62

f. *Rowing* on rowing machine or inclined form.
g. *long sitting; receive and pass ball.*

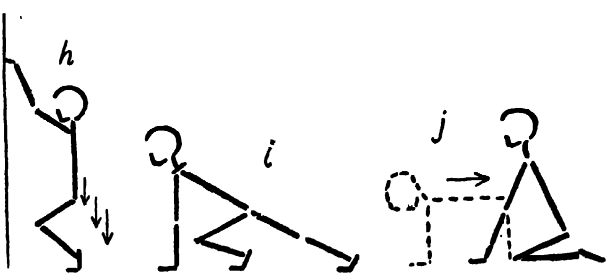


FIG. 63

Weight-bearing Exercises (Fig. 63)

h. *reach grasp Toe standing; double Knee bending and stretching, with bobbing movements.*

i. *crouch position; alternate Leg stretching, with or without spring.*

j. *prone kneeling; sit back on Heels.*

Activities to increase Mobility of Knee Joint

Correct movement in walking must be learnt and practised as soon as possible, and later, walking up- and downstairs and uphill and downhill, breaststroke swimming and other activities involving running and jumping should be encouraged when possible.

THE HIP JOINT

The joint between the spherical head of the femur and the acetabulum is poly-axial and very stable. The range of movement can become limited in any or all directions but the most usual deformity is a combination of flexion, adduction and lateral rotation. Emphasis in mobilising is, therefore, on extension, abduction and medial rotation.

Relaxed Passive Movements of the Hip Joint

ly.; 1 Hip abd. and add., med. and lat. rot., flex. and ext. (pass.)

The leg which is not to be moved is fully abducted and fixed, either by a sandbag or by bending the knee over the side of the plinth, and the patient relaxes. With the forearm supinated, one of the physiotherapist's hands supports under the thigh, and with the other pronated she supports the lower leg at the ankle joint. Traction is given and the leg is moved into abduction (about 30° from the median plane) and adduction. Medial and lateral rotation can be performed by giving traction on the heel and rolling the knee inwards and outwards with a stroking movement (as in using a rolling pin).

Support under the thigh and round the ankle or foot is given for flexion, the hand under the thigh moving as the knee is bent into a position in which the fingers support the knee laterally and the thumb gives overpressure on the front of the knee. This pressure is directed towards the patient's shoulder. The leg is then extended by allowing the heel to come to the plinth first and then straightening the lower leg. Extension is still incomplete in this position and the patient must be moved to *side lying* or *prone lying* for the additional 15° which is possible.

A combination of abduction and lateral rotation, adduction and medial rotation can be done in both hips simultaneously from *crook lying*, and the four angular movements can be combined as a hip rolling, in which case the knee is held in flexion.

FORCED PASSIVE MOVEMENTS OF THE HIP JOINT

Flexion. The patient is relaxed in the *lying* position and the pelvis is fixed by pressure on the thigh of one leg while the other knee is bent on to the chest and directed towards the shoulder, sudden overpressure being given at the limit of the movement.

Extension. This movement is forced with the patient in *prone lying* with the affected knee bent, one hand fixing the pelvis with firm downward pressure while the thigh is levered upwards with the other. When the range of extension is severely limited, this method may be impractical, and in this case the movement may be carried out with the patient *lying* with the other knee fully bent on to the chest.

Abduction. The pelvis is fixed by abducting one leg fully, then with one hand above the hip joint on the affected side, the other grasps the medial side of the thigh and performs the movement, usually with prolonged traction to overcome the tension of the Adductor Muscles.

Circumduction. With the knee flexed throughout, this movement may be done with an upward swing to emphasise flexion.

Lateral and Medial Rotation. In extension, strong traction is given at the ankle with one hand, while the lower end of the femur is screwed into medial and lateral rotation with the other.

With the knee bent and the thigh vertical, upward traction is given while both hands grasp round the lower end of the femur and protect the knee joint. For medial rotation the lower leg is supported by the physiotherapist's forearm, with the leg tucked under her arm, and for lateral rotation it is supported so that the patient's foot lies on the lateral side of her elbow.

ASSISTED EXERCISES FOR THE HIP JOINT

Grasps similar to those used for relaxed passive movements enable the physiotherapist to assist the patient's own efforts to move.

As the limb to be moved is heavy, suspension and the use of roller skates are valuable means of assistance. Suspension for flexion, extension, abduction and adduction may be either axial with manual assistance, or pendular, and the use of tension springs gives a feeling of buoyancy and prevents any jerking as the direction of the movement is reversed. In acute cases, where movement is very limited, vertical suspension at the knee and foot helps relaxation and avoids the centripetal pull of the rope, which presses the joint surfaces against each other, in the axial method. The point of suspension should be high in this case, to flatten the plane of movement as much as possible.

Extension is emphasised in *side lying*, the stationary leg being bent up to fix the pelvis by the tension of the Hamstrings (Fig. 64, left).

For abduction one or both legs can work in *lying* or *prone* *lying*, the legs being as nearly in alignment with the body as possible to get pure abduction (Fig. 64 centre).

Skates can be used in a similar way either on the floor or on hinged and sloping boards.

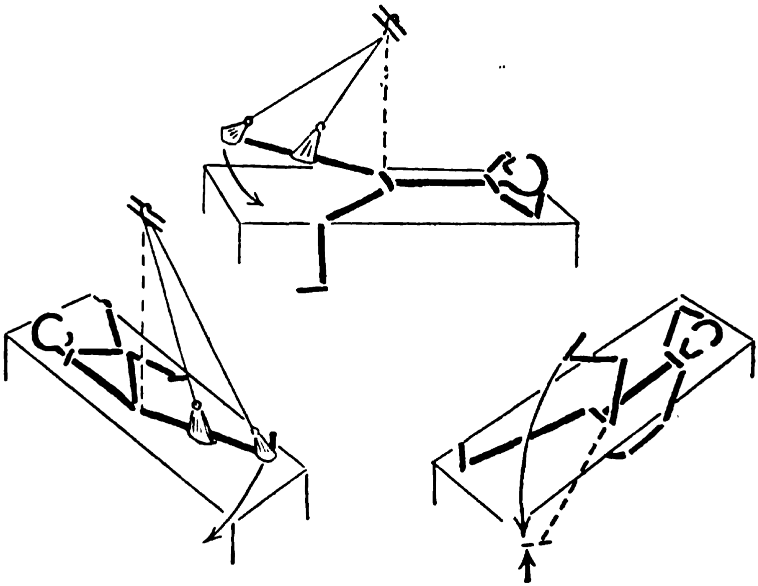


FIG. 64

Rotation is a more difficult problem. In flexion, the leg can be suspended so that the thigh is vertical and the lower leg horizontal and a rotatory movement assisted manually with traction. In extension, traction can be given and movement assisted manually.

EXAMPLES OF FREE MOBILITY EXERCISES FOR THE HIP JOINT

Movement in these joints is usually associated with movement in the spine and in the knees. A combination of hip and knee flexion with lumbar flexion and backward tilt of the pelvis provides a fixed origin for the Hip Flexors and relief of tension on the antagonistic muscles (the Hamstrings), whereas extension of the hip and knee with lumbar extension and a pelvic tilt forwards provides for maximum efficiency of both the Gluteus Maximus and the Hamstrings and a release of tension on the Hip Flexors (including Rectus Femoris).

To increase mobility, full range movement performed with active overpressure and frequent repetitions is required.

Non-weight-bearing Exercises

a. *side lying; one Hip and Knee bending, stretching and Leg carrying backwards.*

b. *grasp high half standing; Leg swinging forwards and backwards.*

c. *prone lying (Knees straight, Toes tucked under); Leg medial and lateral rotation.*

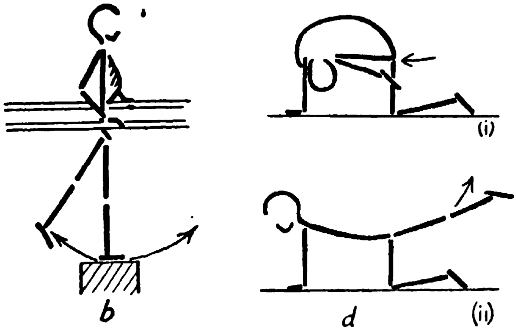


FIG. 65

d. *prone kneeling; one Hip and Knee bending and stretching.*

e. *reach grasp high half standing; one Leg swinging across and sideways.*

Partial Weight-bearing Exercises

f. *heave grasp high half standing; Arm stretching and one Knee bending.*

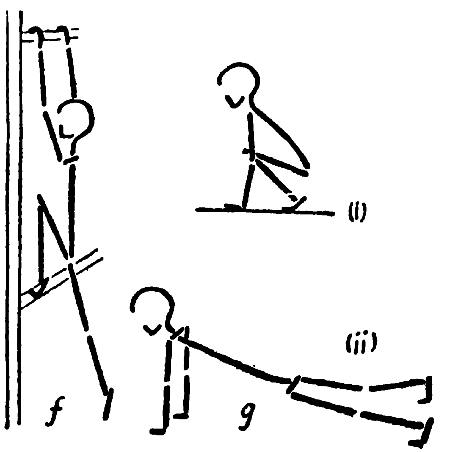


FIG. 66

g. *crouch position; step or spring to stride prone falling*

Weight-bearing Exercises (Fig. 67)

h. *grasp standing; change to fallout sideways position.*
i. *half kneeling, or step standing; forward pressing.*
j. *crouch position; change to stretch standing.*
k. *stride standing; Pelvis and Trunk rotation.*
l. *standing; step and hop with one Leg swing sideways.*

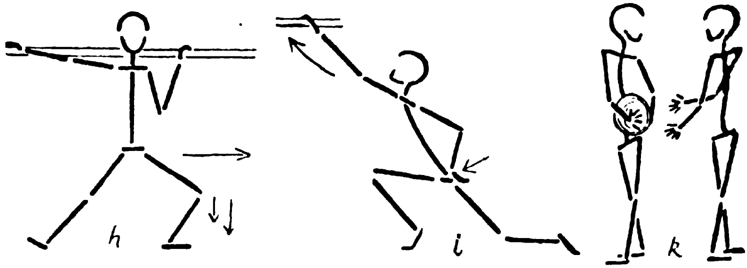


FIG. 67

Activities suitable for increasing Hip Mobility

Examples of these are walking, running, climbing stairs, cycling, rowing, breast-stroke swimming and golfing.

THE JOINTS OF THE PELVIS

The movements in these joints are very slight and are associated with those in the hip and lumbar spine.

During pregnancy, however, the pelvic joints become more mobile as the result of the slackening of their ligaments, and allow a rotation of the hip bones on the sacrum which increases the capacity of the pelvis. These ligaments tighten again during involution and the joints regain their stability.

Forced Passive Movements of the Sacro-iliac Joint

These may be designed to correct what is thought to be a backward rotation strain of the hip bone on the sacrum.

A firm couch is used to support the patient in *side lying* with hips and lumbar region flexed, the uppermost arm resting behind the back. *Standing* facing the patient the physiotherapist exerts pressure forward and downward on the posterior region of the hip bone while the other hand gives counter pressure on the shoulder.

Other movements are encouraged when the hip and lumbar spine are mobilised.

THE JOINTS OF THE VERTEBRAL COLUMN

Movement between any two adjacent vertebrae is very limited, but the sum of these small movements results in the production of a considerable range in the spine as a whole. The movements permitted vary in the regions according to the shape and thickness of the interarticular discs, the direction of the articular surfaces and the shape of the spinous processes. The spine can be mobilised as a whole or in regions.

(*A*) *THE LUMBAR REGION*

Relaxed Passive Movements of the Lumbar Region

Owing to the weight of the body these are most easily performed in suspension, the best leverage being obtained by fixing the upper part of the body and moving the lower.

s. ly. (*P. and L. susp.*); *Lumbar flex. and ext.* (*pass.*)
For flexion and extension the patient lies on his side with the pelvis and legs in axial suspension. With the hips and knees extended the lower half of the body is swung forwards and backwards.

ly. (*P. and L. susp.*); *Lumbar s. flex.* (*pass.*)
The pelvis and legs are moved from side to side, fixation may be assisted by pressure at the waist on the side towards which the movement takes place.

Forced Passive Movements of the Lumbar Region

Flexion. The patient lies with hands behind his head, both hips and knees are fully bent on to the chest and the knees are directed towards the shoulder until the buttocks leave the plinth, then the movement is forced by sudden pressure on the anterior aspect of the knees.

Extension. With the patient prone, one of the physiotherapist's hands is placed on the lumbar region and her other forearm supports under both thighs and the latter are then lifted vigorously. The forearm must be held horizontally throughout to avoid torsion.

Side Flexion. The patient supports himself in side lying and keeps his own legs straight. The physiotherapist stands behind and exerts firm downward pressure on the uppermost side of the waist with one hand and, using this hand as a fulcrum, she then grasps above the knees and lifts both legs with a swing in an upward direction.

Assisted Exercises for the Lumbar Region

These are usually given manually as the patient performs the movement actively with the legs in suspension or from *hanging*.

Some positions hold the lumbar spine at the limit of the free range of movement.

Flexion. *crk. sitt., lg. sitt., stp. sitt. or stp. kn.* . '.
Extension. *sit. ly., ly.* (pillow under waist).

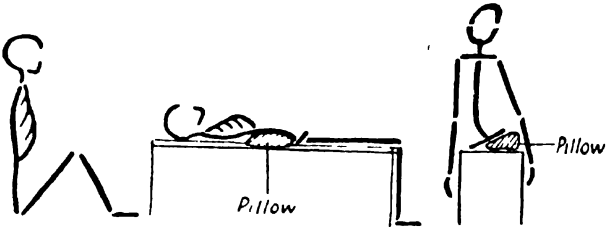


FIG. 68

Side flexion. *s. sitt., sitt.* (pillow under one buttock).

EXAMPLES OF FREE EXERCISES FOR THE LUMBAR JOINTS

a. (*i*) *crook lying* or
(*ii*) *grasp crouch sitt.; Pelvis rolling.*

b. *stride long* or
stride crook sitting; Trunk bending forward and raising.

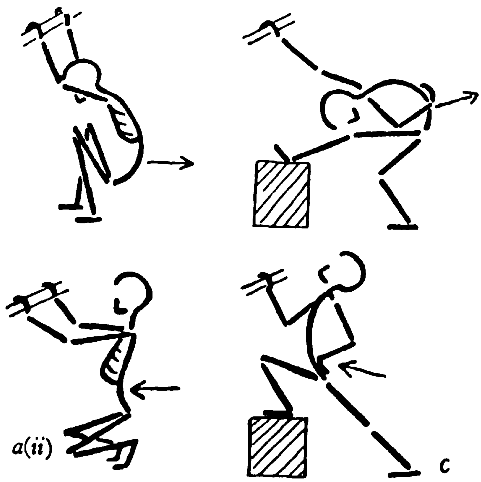


FIG. 69

c. ½ *reach grasp step standing; Trunk bending forward and arching backward.*

d. *prone kneeling; Trunk side bending.* (Wag Tail.)
e. *half standing (Foot support sideways); Trunk bending sideways.*
f. *hanging; Leg swinging sideways (from waist).*

(B) THE THORACIC REGION

Flexion, extension and side flexion are all limited in this region but rotation is free. The tendency to adopt a flexed position and so to restrict the movement of the ribs in inspiration makes extension and straightening of major importance.

To be effective, passive movements in this region must usually be forced in character.

Forced Passive Movements of the Thoracic Region

Extension. The thoracic region can be elongated and straightened with the rest of the spine by prolonged steady traction in a Sayre's Sling or other Head Traction apparatus.

Alternatively, the heel of one of the physiotherapist's hands, reinforced by the other, may be placed centrally on the convexity of the mid-thoracic region with the patient relaxed in *prone lying.* The patient is then instructed to 'breathe in' and then 'out', and at the end of expiration sudden downward pressure with body weight is given to flatten the spine and force extension.

Side Flexion. In cases of severe structural scoliosis prolonged and steady forcing is obtained by some form of corrective plaster jacket, such as the Risser Jacket. In less severe cases manual methods may be used, e.g. to force side flexion to the left, the patient's starting position is *right head rest, left wing high ride sitting* and the physiotherapist stands behind and localises the movement by pressure on the angle of the ribs with her fist while her right hand grasps under the patient's right upper arm and levers the trunk upwards and over to the left. Some rotation to the right is usually added in an attempt to combat the inevitable rotation which accompanies lateral flexion in structural cases (Fig. 70*a*).

Rotation. From *side lying*, with the under leg in line with the body, the shoulder which is uppermost is forced backwards and downwards to the couch, while the ilium is pressed forwards and downwards.

By another method, the patient sits astride with arms folded and the physiotherapist stands at the side towards which the movement is to take place and vigorously pushes the shoulder on this side as she pulls the other forwards.

ASSISTED EXERCISES FOR THE THORACIC SPINE

During these exercises the lumbar region must be controlled as far as possible by the starting position. In the upright position the weight of the head and shoulders has a telescoping effect on the spine; when this weight is removed from it by traction or by using the horizontal position the spine tends to straighten and elongate and the range of movement is increased.

Active extension is assisted by traction on the tightened anterior

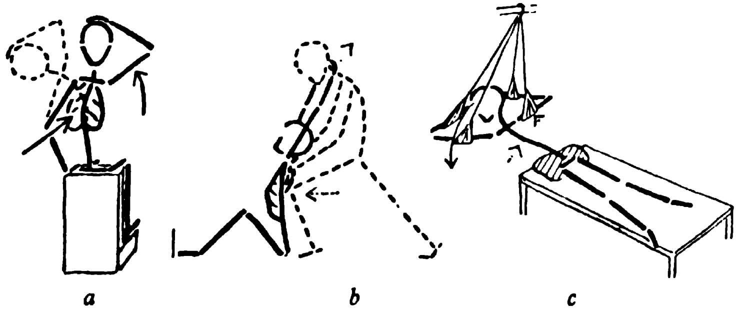


FIG. 70

structures and by a deep inspiration (Fig. 70*b*); side flexion can be localised and assisted when the trunk is suspended horizontally in extension (Fig. 70*c*).

EXAMPLES OF FREE EXERCISES FOR THE THORACIC SPINE

Relaxation in *crook lying* and deep breathing help to straighten the spine.

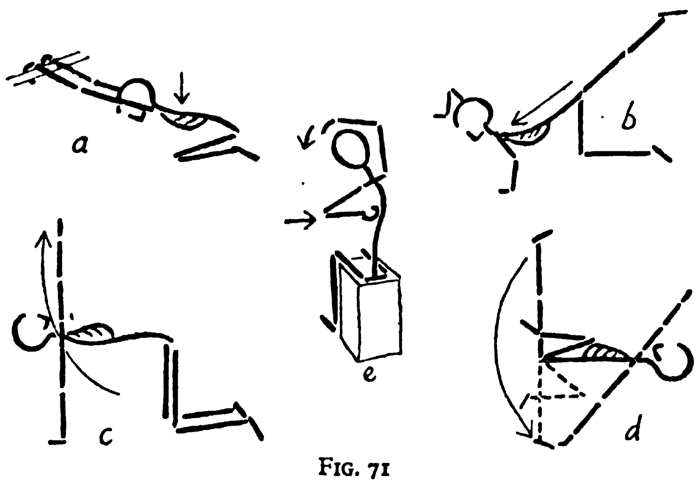


FIG. 71

a. *stretch Wrist support stoop kneel sitting; Trunk pressing downward.*
b. *inclined prone kneeling; Leg lift crawl* (Klapp).
c. *prone kneeling; Trunk turning with loose Arm swinging.*
d. *yard crook or Leg lift lying; Trunk rotation.*
e. *under bend ride sitting; Trunk side bending.*
f. *inclined prone kneeling; low dog crawl* (Klapp).

(C) *THE CERVICAL REGION*

Movement in this region and that at the atlanto-occipital joint are virtually inseparable. Flexion, extension and lateral flexion are free but rotation is limited except at the atlanto-axial joint.

Relaxed Passive Movements of the Head and Neck

The patient lies relaxed on a low plinth with head supported by the physiotherapist's hands cupped round the occipital bone, as she sits with legs astride and elbows resting on her knees. Traction is given in the long axis of the spine prior to all movements.

Forced Passive Movements of the Head and Neck

In the treatment of Torticollis the child's head is grasped between the hands and his shoulders are fixed by the mother. Traction is given first to stretch the neck, which is then bent to one side and then rotated in the opposite direction, thus obtaining the maximum stretch on the shortened sternomastoid muscle. The child's mother is usually taught to perform the stretching movement so that it can be repeated at frequent intervals during the day.

Other Forced Passive Movements of the Head and Neck are omitted here as they require special care and precision to be effective. A description of their technique can be found in books which specialise in this type of movement.

Head Traction

Head traction can be arranged so that it is either intermittent or prolonged. Manual traction, which is usually relatively intermittent, is performed by the physiotherapist with the patient *sitting* or *lying*; in the latter case the patient's feet or shoulders are fixed to counterbalance the effect of the traction. The physiotherapist's hands are cupped round the occipital bone and under the jaw, care being taken to avoid pressure on the larynx by the hand on the jaw. Many methods of applying traction by mechanical means are in common use. To ensure relaxation of the neck muscles and therefore maximum effect on the spine it is essential that the method used is safe and comfortable and that the traction is maintained for a considerable period of time once the patient has become accustomed to it.

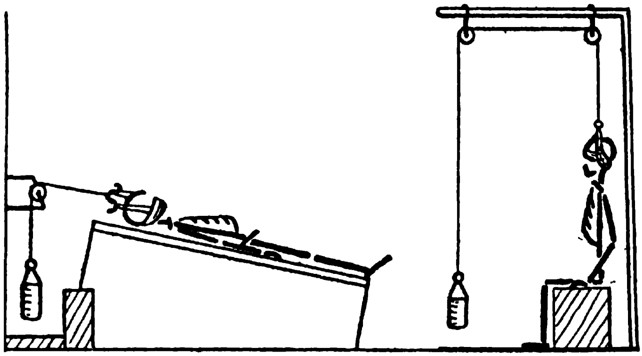


FIG. 72. Head traction

ASSISTED EXERCISE FOR THE HEAD AND NECK

When the shoulder girdle is fixed, manual assistance can be given to all movements by the physiotherapist or by the patient himself.

FREE EXERCISE FOR THE HEAD AND NECK

Rapid full-range movements of the head tend to give a feeling of giddiness and so these exercises should be done in the patient's own rhythm, often with a rebound or a pressing movement at the limit of the range and in bouts of short duration. The shoulder girdle may be fixed or the movement can be continuous with that of the rest of the spine, preferably with the objective interest of seeing or touching some object.

a. *low grasp sitting; Head bending, stretching, side bending, rolling and turning.*
b. *prone kneeling; Head bending, stretching, side bending, rolling and turning.*
c. *standing; throwing and catching beanbag, quoit or ball.*
d. *sitting or crook sitting; Trunk bending to put right Ear on left Knee and raising with Head turning to right.*

(D) THE WHOLE SPINE

EXAMPLES OF FREE EXERCISES FOR THE WHOLE SPINE

Many activities using heavy balls, Indian clubs, sticks and hoops promote a wide range of trunk movement.

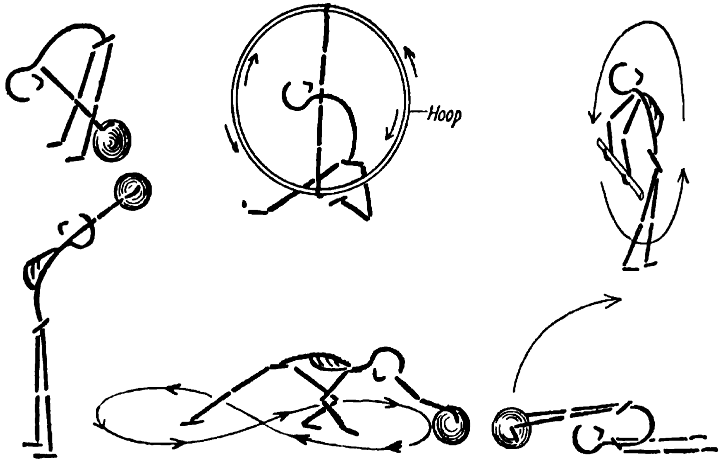


FIG. 73

THE THORAX

The ribs move in respiration and with the thoracic spine. When the range of the respiratory excursions is reduced, the thorax may be either expanded and unable to relax, or tense and unable to expand. In the first case, mobility can be improved by relaxation and breathing exercises which emphasise expiration, and in the second, relaxation and breathing exercises to improve the efficiency of the inspiratory muscles are required.

Expiratory Exercises

These are general breathing exercises with emphasis on expiration and relaxation. The patient is taught to reverse the effort of breathing so that expiration becomes a muscular act and inspiration the recoil from it. Inspiration must be easy and as shallow as possible, expiration is prolonged and assisted by pressure on the antero-lateral aspects of the lower part of the thorax. General relaxation is practised between each exercise at first, as controlled breathing is very tiring and requires much concentration. Exercises to mobilise the shoulder girdle and thoracic spine are also used and are timed to assist the movements of the new pattern of breathing.

EXAMPLES OF EXERCISES TO INCREASE THE EXPIRATORY RANGE

a. *half lying; general relaxation.*
b. *half lying; Diaphragmatic breathing, emphasising relaxation of abdominal wall on inspiration and contraction on expiration.*

c. *half lying; breathing with pressure during expiration on lower ribs by the patient's own hands, a strap or by the physiotherapist's hands.* Coarse vibrations may also be given to increase the effect of the pressure.
d. *half lying; breathing with Hip and Knee bending to press on chest during expiration.*
e. *relaxed stoop sitting; Trunk raising with inspiration and relaxing on prolonged expiration.*
f. *sitting; Trunk turning with loose Arm swinging, breathing out and relaxing during turn, breathing in coming forwards.*

Inspiratory Exercises

These may be required to affect the whole thorax (general) or a specific area (local).

General. To increase the respiratory range generally, the muscles of inspiration must be exercised progressively and freed from the opposition of tight anterior structures, notably the Pectoral Muscles, and the weight of the head and shoulders which may cause stooping posture. Mobilisation of the thoracic spine and shoulder girdle, correction of posture and relaxation are essential in addition to teaching the patient how to use the whole chest and so train a new and better habit of breathing. Deep inspiration is taught in the patient's own time with the trunk supported, relaxed and straight. *Half lying* is preferred, as pressure on the back is insufficient to impede movement at the costo-vertebral joints and the Diaphragm is freed from excessive abdominal pressure.

Movement in all parts of the thorax is encouraged by light pressure on specific areas such as the lower ribs anteriorly or posteriorly (Diaphragmatic, Basal or Lower Costal Expansion), or under the arms (Axillary or Lateral Costal Expansion), or over the clavicles (Apical Expansion). Exercises in which the arms are rotated laterally, or elevated, and the spine is extended assist expansion of the thoracic cage, and when suitable, activities which make the patient laugh and get out of breath increase the respiratory excursions.

EXAMPLES OF EXERCISES TO INCREASE THE INSPIRATORY RANGE

a. *half lying; relaxation and general deep breathing.*
b. *half lying; Lower Costal Expansion—against resistance of webbing strap. 'Enlarge all the way round.'*
c. *relaxed; crook sitting; Back arching with deep inspiration.*
d. *sitting; Arm rotation outwards with deep inspiration.*
e. *relaxed sitting; Arm lifting and Trunk raising with inspiration as in yawning and stretching.*
f. *skipping, running or swimming to 'Get out of breath'.*

Local. The patient may be required to localise respiratory movements to a specific area, to affect the underlying lung tissue. Correct posture and alignment are established first, and the area is localised by firm manual pressure against which the patient must try to push and withdraw. Concentration and patience are required, therefore practice must be frequent but of short duration.

THE SHOULDER GIRDLE

Limitation of movement is usually the result of muscular tension which elevates the scapulae and draws them forward round the chest wall. Mobilising methods include relaxation and exercises to increase movement in the shoulder joint and upper back.

EXAMPLES OF FREE EXERCISES TO MOBILISE THE SHOULDER GIRDLE

a. *sitting; Shoulder shrugging.*
b. *prone kneeling; upper Back rounding and flattening.*
c. *bend sitting; Shoulder girdle rolling.*
d. *sitting; Arm medial and lateral rotation.*

THE SHOULDER JOINT

The head of the humerus articulates with the glenoid cavity of the scapula at the gleno-humeral or shoulder joint. In free movements of the arm, movement at this joint is always associated with that at the joints of the shoulder girdle and it is only under artificial conditions that they can be localised, as, for example, when the shoulder girdle is fixed by external pressure or when gleno-humeral movement is severely limited pathologically.

Pain in any part of the arm frequently results in the shoulder joint being fixed or held to the side in adduction, semiflexion and medial rotation. Limitation of extension, abduction and lateral rotation in the glenohumeral joint [while shoulder girdle movement remains free] results in a characteristic alteration in the normal sequence of joint movement when elevation of the arm is attempted. The relative ease with which scapula movement takes place, as opposed to the difficulty in producing glenohumeral movement, leads to a so-called reversal of scapulo-humeral rhythm. This alteration in the normal pattern of movement may be compared to that of a limp in walking and must not be allowed to continue. Scapula movement, except perhaps in the final stages of elevation, is essentially postural in character, the scapula being stabilised as a basis for glenohumeral movement. This stabilisation, however, is dynamic and not static in that it is constantly being adapted to the circumstances of the movement. Scapula stabilisation (or shoulder girdle control) can be achieved passively by manual pressure on the clavicle and the spine of the scapula; it is preferable, however, that the patient should learn to control it by his own efforts. A preliminary active depression of the shoulder girdle or 'pressing down' of the elbow prior to the effort to abduct will often prove a useful method of obtaining a satisfactory movement and the patient is asked to 'feel' the correct pattern or observe it in a mirror. It is interesting to observe that the normal sequence of movement remains unaltered when diagonal spiral patterns are used to re-educate movement.

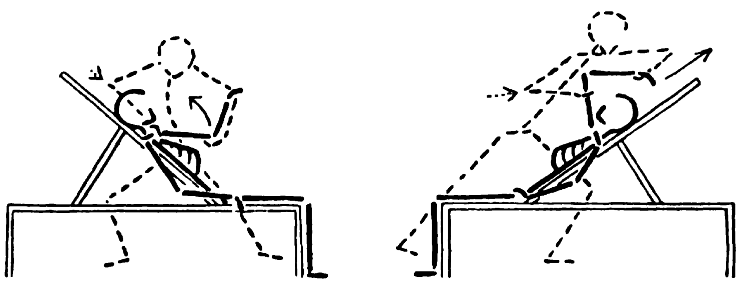
Relaxed Passive Movements of the Gleno-humeral Joint

With Shoulder Girdle fixed

ly. or ½ ly.; S. abd., add., flex. ext. (*circum.*), *lat. rot., med. rot.* (*pass.*)

The patient's back and head are supported to ensure relaxation, the point of the shoulder being free at the side of the plinth, to prevent the necessity of altering the position to obtain full extension. One of the physiotherapist's hands fixes the shoulder girdle by pressure on the acromion and lateral third of the clavicle, the other grasps just above the elbow, which is bent to a right angle, and supports the patient's forearm on her own forearm. Traction is given to depress the head of the humerus in the glenoid cavity as the arm is moved into abduction (about 80°) with sufficient lateral rotation to bring the forearm into the same plane (see Fig. 74).

Flexion and extension can be done in either abduction or



With Shoulder Girdle Fixed — Combined with Scapula Movement

FIG. 74. Shoulder Flexion and Extension

adduction. In abduction, flexion is across the body and extension backwards over the side of the plinth, traction being given in the plane of the scapula. The natural pattern of arm movement, in which the elbow is flexed with shoulder extension and extended with shoulder flexion, is followed. It is not necessary to fix the shoulder girdle for rotation movements, and these, too, can be performed in either abduction or adduction with the patient's elbow flexed to a right angle. One of the physiotherapist's hands acts as a fulcrum and gives traction above the elbow, while the other uses the forearm as a lever to produce the movement.

Combined with Scapula Movement (Fig. 74)

The arm is grasped at the elbow and across the wrist, the movements being the same as with the shoulder girdle fixed, except that abduction is extended and combined with maximum lateral rotation to obtain full elevation. Elevation through flexion is usually combined with elbow extension.

Forced Passive Movements of the Gleno-humeral Joint

These movements aim at freeing the head of the humerus in the glenoid cavity. Lateral rotation, downward and backward gliding are essential movements and the most likely to be limited.

Distraction or separation of the joint surfaces is performed first. The patient sits on a chair and the physiotherapist supports one foot on the side of the chair, so that her knee presses on and fixes the axillary border of his scapula. With the shoulder joint in about 30° of abduction, the arm is grasped above the elbow and traction is given in the long axis of the humerus.

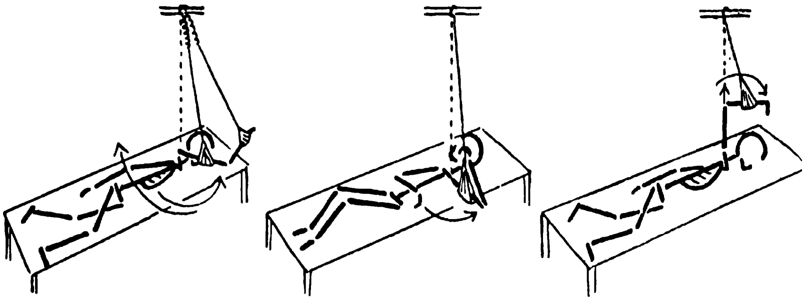
Secondly, with the shoulder adducted, the shoulder girdle is fixed by downward pressure of one hand, while the other grasps at the elbow and moves the humerus vertically upwards and downwards within the glenoid cavity.

Thirdly, with the patient *lying*, one hand is placed over the head of each humerus and the bones are pressed backwards by firm downward pressure to the supporting surface.

Examples of Assisted Exercises for the Shoulder

The range of movements in the shoulder may appear to be greater than they are when they are augmented by movements in the spine. For example, the hand can be lifted higher during elevation through flexion by extending the lumbar spine, and the elbow can be raised by side bending to the opposite side, while lateral and medial rotation are increased apparently, by extension and flexion of the spine respectively. Spinal movement can be controlled by suitable starting positions for the exercises or by using both arms simultaneously, either together or in opposition.

The shoulder girdle may be fixed or free during manual assistance which can be given in conjunction with the mechanical support of slings, using *side lying* for flexion, extension and rotation, and *lying* for adduction and abduction. In *lying*, flexion of the elbow, so that the patient holds the rope, shortens the leverage but ensures the



Flexion and Extension Abduction and Adduction Rotation

FIG. 75

lateral rotation which is essential for abduction. *Side lying*, with the forearm supported so that the upper arm is vertical, is used for rotation, traction prior to movement being given by pressing the scapula to the trunk and a counter pull above the elbow.

Flexion and extension can be self-assisted by clasping the hands

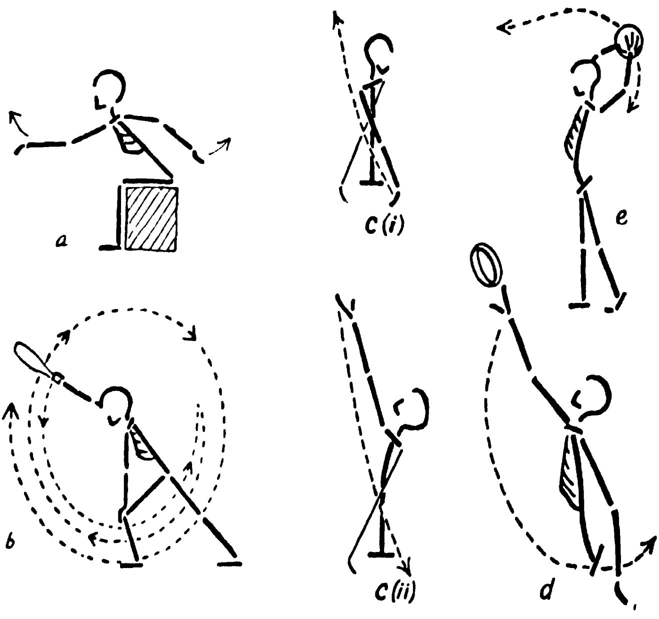


FIG. 76 Free Exercise for the shoulder

or supporting under the elbow, and the buoyancy of water will help abduction when the body is upright and submerged. Rotation is encouraged by rubbing the back vigorously with a short towel held vertically.

EXAMPLES OF FREE EXERCISES FOR THE SHOULDER JOINT (Fig. 76)

a. *stoop stride sitting; Arm swinging forward and backward.*
b. *half reach fallout standing; one Arm swinging backward, forward and circling.*
c. *Arms crossed sitting; one Arm lateral rotation with swinging obliquely forwards and upwards.*
d. *stride standing; Arm swinging across, sideways and sideways-upwards and circling.*
e. *walk standing; overhead throw.*
f. *walk standing; throw and catch quoit.*

Strengthening exercises given in the pain-free range are of great importance in the treatment of stiff shoulders as the Deltoid muscle is coarse in texture and wastes rapidly.

ACTIVITIES FOR THE SHOULDER

Many household activities such as polishing, cleaning windows, scrubbing floors, hanging clothes on a line and household decorating are useful in promoting movement and strength in the shoulder region. Recreational activities such as netball, basketball, deck quoits and handball encourage movement with objective interest.

THE ELBOW JOINT

The humerus articulates with both the radius and the ulna at the elbow. The trochlea surface of the humerus and the trochlea notch of the ulna form the medial part, the capitulum of the humerus and the circular facet on the head of the radius form the lateral part of the joint. In full extension the supinated forearm is abducted to about 10° at what is known as the 'carrying angle', but in flexion it lies in the same plane as the upper arm. During flexion, however, there is normally a slight medial rotation of the humerus so that the fingers are directed towards the middle of the clavicle.

Stiffness resulting from traumatic injury is mobilised by free exercise only, the emphasis being on the maintenance of flexion, which is essential to bring the hand to the mouth and is usually performed against the resistance of the force of gravity.

RELAXED PASSIVE MOVEMENTS OF THE ELBOW JOINT

½ ly.; Elb. flex. and ext. (pass.)

The lower end of the humerus is supported by one of the physiotherapist's hands while the other grasps across the wrist, fingers anteriorly, thumb posteriorly. When movement is localised to the elbow joint the forearm is usually supinated throughout and full extension is ensured by upward pressure of the hand grasping above the elbow, allowance being made for the 'carrying angle'.

It is preferable, however, as a general rule, to follow the natural movements of the arm as a whole, combining extension of the shoulder, with flexion of the elbow and supination to bring the fingers towards the clavicle, and following this by flexion of the shoulder, with extension of the elbow and pronation.

FORCED PASSIVE MOVEMENTS OF THE ELBOW

These are rarely if ever used, except when forcible stretching of the common extensor tendon from the lateral epicondyle is required, as for a 'Tennis Elbow'. With the arm abducted, the elbow is forcibly extended while the wrist is held in full flexion and the forearm in full pronation.

ASSISTED EXERCISES FOR THE ELBOW

Mechanical assistance is unsuitable for this joint because of the danger that it may develop into passive traction, which is contra-indicated in many cases. Manual assistance can be given with care, and a mild form of self-assistance is encouraged by the patient 'creeping' or 'walking' the fingers up and down a wall or across a table.

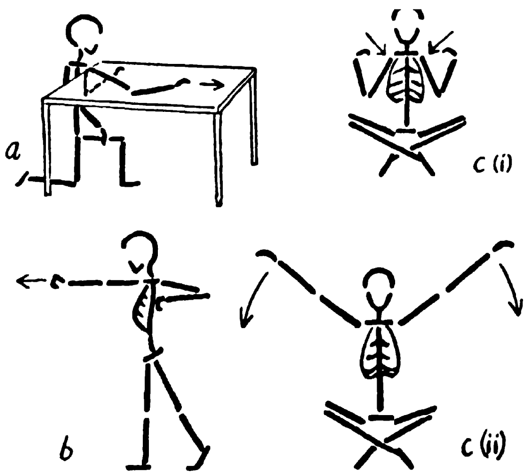


FIG. 77

EXAMPLES OF FREE EXERCISES FOR THE ELBOW

In the early stages of treatment the passive traction exerted by the force of gravity can be eliminated by suspension or by the support of a polished table or re-education board. Associated movements of the shoulder and forearm assist the action of the muscles which pass over both joints, and these should be encouraged.

a. *Arm support sitting or half kneeling; Elbow flexion and extension.*
b. *walk standing; Arm flexion and extension, 'Punching' movement.*
c. *cross sitting; Arm swinging to touch Shoulder and tap floor.*
d. *stride standing; Arm bending and stretching in all directions, rhythmically.*

THE RADIO-ULNAR JOINTS

At the superior radio-ulnar joint the head of the radius rotates in the osseo-fibrous ring formed by the annular ligament and the radial notch of the ulna. There is a fibrous connection between the shafts of the bones which may be referred to as the middle radio-ulnar joint and at the inferior joint the ulnar notch of the radius, carrying the hand with it, glides round the head of the ulna. When the elbow is extended the movements of pronation and supination are usually accompanied by medial and lateral rotation at the shoulder joint, therefore to localise the movement to the radio-ulnar joints the elbow is flexed to a right angle and the upper arm is held still.

RELAXED PASSIVE MOVEMENTS OF THE RADIO-ULNAR JOINTS

B. sup. sitt.; pron. and supin. (pass.)

The upper arm is fixed and the elbow flexed to a right angle. With her forearm in line with that of the patient, the physiotherapist grasps as if to shake hands, extending her index and second fingers across the anterior aspect of the wrist to stabilise this joint. With the other hand she supports round the patient's elbow. Traction is given in the long axis of the forearm and the movement is one of rotation about this axis.

FORCED PASSIVE MOVEMENTS AT THE RADIO-ULNAR JOINTS

1. *At the Inferior Radio-ulnar Joint*

The head of the ulna moves relatively backwards on the radius during pronation and relatively forwards during supination. As the movement is only free in the mid-position, this accessory movement is performed in that position with the patient's elbow flexed and supported. The lower end of the radius is fixed with one hand while the head of the ulna is grasped and moved by the other.

2. *At all the Radio-ulnar Joints*

The radius is also free to move upwards and downwards on the ulna through a small range. For the downward movement (*a*) with the elbow flexed counter pressure is given just above the elbow and traction is exerted in the long axis of the forearm by grasping round

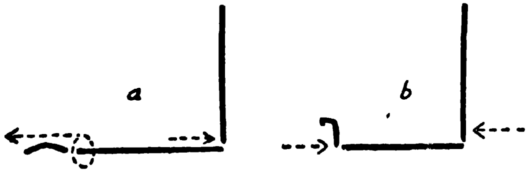


FIG. 78

the wrist. For the upward movement (*b*) fixation is given behind and above the elbow, while pressure is exerted on the base of the thumb with the wrist extended.

ASSISTED EXERCISES FOR THE RADIO-ULNAR JOINTS

Manual assistance can be given to the movement while grasping the lower end of the bones. Associated movements of the hand, i.e. making a fist with supination, and opening the hand with pronation, assist the movement.

Additional leverage is obtained for mechanical assistance when the patient grasps a stick in the hand (Fig. 79, left).

EXAMPLES OF FREE EXERCISES FOR THE RADIO-ULNAR JOINTS

a. *Forearm support sitting; pronation and supination.*

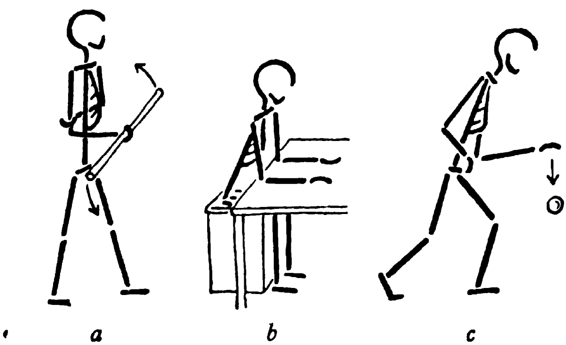


FIG. 79

b. *Forearm support sitting; pick up cards from a pack and turn them to face upwards on a table.*

c. *walk standing; bounce a ball and 'throw and catch' a beanbag.*

Activities to increase the Range of Pronation and Supination

Many household activities encourage movement in these joints, such as screwing and unscrewing, using a screwdriver, turning door handles, and wringing out a dishcloth.

THE JOINTS OF THE HAND

The prime function of the hand is to grip, and movement in its numerous joints enables it to be moulded to the wide variety of shapes and sizes with which it comes in contact.

Relaxed Passive Movements of the Hand

The Wrist Joint

A. supp. sitt.; Wr. flex. and ext., abd. and add., circum. (pass.)

The patient sits on a chair with the elbow semi-flexed and supported and the forearm supinated. The physiotherapist supports and fixes the forearm above the wrist with one hand, and grasps the patient's hand from the ulnar side with the other, her thumb straight and lying comfortably on the back of the hand and her fingers in the palm. Traction is given and then the wrist is flexed and extended.

It is important to observe the natural movement of the fingers which accompanies these movements, i.e. flexion of the fingers with extension of the wrist and vice versa, in response to tension of the tendons passing across the wrist. A small degree of pronation permitted with extension of the wrist and supination with flexion will also allow the natural pattern of movement to be followed.

Abduction and adduction are done with the same grasp; note that the range of adduction is greater than that of abduction.

Circumduction is performed in either direction by combining the four angular movements.

The Carpometacarpal Joints

(*i*) *of the Fingers.* A gliding movement at these joints is associated with movement at the intermetacarpal joints, which is very slight on the radial side of the hand but freer on the ulnar side.

Two adjacent metacarpal bones are grasped and moved forwards and backwards on each other; all these joints may be moved simultaneously, the palm being moulded to form an arch and then flattened.

(*ii*) *of the Thumb.* Owing to the shape of the articular surfaces, flexion at this joint is accompanied by medial rotation and is then called opposition. Thus the ball of the thumb can be brought into contact with the palmar surfaces of the fingers when they are slightly flexed.

With one hand the physiotherapist grasps round the carpal bones to fix the wrist and to support the forearm, and with the other hand gives traction on the thumb prior to flexion with medial rotation (opposition) and extension, both of which occur in the plane of the palm of the hand.

Abduction and adduction are at right angles to the plane of the palm of the hand and when all the angular movements are carried out in sequence circumduction results, i.e. opposition, adduction, extension, abduction.

The Metacarpophalangeal Joints

When each joint is moved separately the metacarpal bone is fixed and the proximal phalanx grasped. Traction is given and the joint is moved through its full range of flexion, extension, abduction, adduction and circumduction. It is important to notice that flexion at these joints directs the fingers across the palm of the hand towards the thenar eminence.

With the exception of the thumb, all these joints can be moved together, in which case the physiotherapist fixes the patient's hand and wrist with one hand and grasps the tips of all four fingers with the other. Traction is given and the movement performed with the fingers straight. Flexion must be at the correct angle and abduction and adduction are achieved by moving all the fingers first to the radial and then to the ulnar side. Circumduction combines these movements.

A considerable degree of separation of the joint surfaces takes place during traction and an accessory movement of rotation can be performed. During this movement care must be taken to ensure that traction is always in the long axis of the joint, otherwise strain or dislocation may result.

The Interphalangeal Joints

Each of these joints can be moved separately by fixing the bone on the proximal side of the joint and moving the bone which is distal to it. As the tendons inserted distal to these joints also pass over the neighbouring joints, the latter must be positioned to eliminate tension which would otherwise prevent full range movement. All the interphalangeal and metacarpophalangeal joints of the fingers can be flexed and extended together. The physiotherapist grasps round the wrist with one hand and places the other on the dorsum of the patient's fingers, so that her fingers point in the same direction as those of the patient. The metacarpophalangeal joints are fully flexed first and then, as the proximal and finally the distal interphalangeal joints follow, the metacarpophalangeal joints are extended to give room for the finger tips and reduce the tension of the long extensor tendons. Extension in the proximal and distal interphalangeal joints follows progressively.

Ease of movement is achieved by following the natural pattern and allowing extension of the wrist with flexion of the fingers and vice versa.

Forced Passive Movements of the Hand

These consist of accessory movements only, other Forced Passive Movements are said to reduce rather than to increase mobility.

The Wrist and Mid-carpal Joints

With the patient's hand in pronation the physiotherapist grasps round the lower end of the radius and round the distal row of carpus. Traction is given in the long axis of the forearm and then the patient's hand is moved vertically upwards and downwards on the forearm.

The Metacarpal and Intercarpal Joints

The heads of two adjacent metacarpal bones are firmly grasped and they are moved in an antero-posterior direction upon each other. Movement between the 4th and 5th is relatively free compared with that between the 2nd and 3rd. Following this the palm is moulded and hollowed to form an arch and then flattened.

The Metacarpophalangeal Joints

The head of the metacarpal bone is firmly fixed and the proximal phalanx grasped between the thumb and fingers. Traction is given in the long axis of the joint and considerable separation of the articular surfaces results and small gliding movements in an antero-posterior direction are permitted. When the joint is slightly flexed a considerable degree of rotation is possible.

Assisted Exercises for the Hand

Manual assistance can be given using grasps similar to those used for relaxed passive movements. Mechanical assistance is unsuitable, although sometimes a light elastic recoil is arranged to assist wrist or finger extension in cases where flexion contracture is likely to occur.

Examples of Free Exercises for the Hand

As the hand is a functional unit, there is little doubt that movements which use the hand as a whole are the most beneficial in promoting mobility. Movements for individual joints in the fullest possible range can be given, preferably with the hand immersed in warm water or after wax treatment. Care must be taken to see that neighbouring joints are correctly positioned, i.e. fingers flexed to gain full extension of the wrist.

a. *sitting; grasping a stick.*

b. *sitting; flexion and extension at the metacarpophalangeal joints* (keeping the interphalangeal joints extended, draw the tips of the fingers and thumb together, then flatten the hand and spread the fingers).

This and many other movements are very satisfactory when done with the objective aim of gathering in or spreading out some substance in a tray, such as sand, rice or beans.

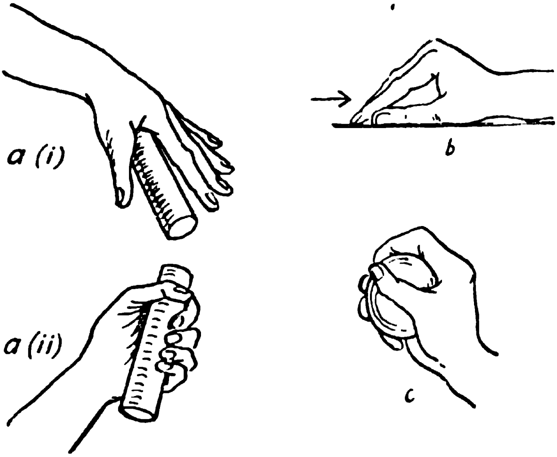


FIG. 80

c. *standing; fit Hand round a soft ball, squeeze it repeatedly and then let go.*
d. *sitting; grasp rolling pin* (or pole about 2 inches in diameter) *and roll it forwards and backwards on the thighs.*
e. *sitting; tie and untie knots.*
f. *sitting; transfer matches from one box to another about 6 inches away, each match is picked up separately, the first being held between the thumb and 1st finger, the second between the thumb and 2nd finger and so on.*

8

CRAWLING EXERCISES

CRAWLING is a natural and instinctive mode of progression used by most children before they walk.

In the horizontal or prone position on 'four feet', the spine is relieved of weight and tension and it becomes more mobile, permitting greater freedom of movement and harmonious development of the Trunk Muscles. As the pattern of movement used in walking and running is based on that used in crawling exercises, these are used by the child as a method of progression until he has learned to balance himself on two feet.

Modifications of these natural crawling movements were first made by Professor Klapp of Dresden, and were used by him in the treatment of scoliosis, as he had observed that four-footed animals did not develop this deformity. Later they were adapted for use in the treatment of other spinal deformities, and although some of those now used differ slightly from those he originally used, they are known in general as Klapp's Crawls.

Crawling exercises are considered primarily as mobility exercises but they also improve muscle power and co-ordination. The rhythm of continuous repetition which is used in their performance reduces fatigue and once learnt they can be carried out for considerable periods of time.

THE POSITION OF THE TRUNK

Movement is localised to specific regions of the spine by altering the position of the trunk. The nearer the trunk is to the vertical position the lower in the spine is the area of greatest mobility, and the further the inclination of the trunk forwards, the higher it becomes. Lateral mobility is also increased with the degree of extension.

Crawling *from the prone kneeling position*

With the trunk in the horizontal position lateral movement takes place in all regions, but chiefly in the lumbar area.

Crawling *from the inclined prone kneeling position*

In the inclined or 'deep' position lateral movement takes place mainly in the thoracic region which is also extended, the lumbar region being flexed and relatively fixed.

EXAMPLES OF CRAWLING EXERCISES

a. *prone kneeling; Dog Crawl*

From the prone kneeling position the whole spine is bent laterally by moving the opposite hand and knee forwards, the head is bent (not rotated) to the side of the forward knee so that the ear rests on that shoulder, and the hip joint on this side is medially rotated so that the lower leg projects sideways. The lateral bending is then reversed by moving the opposite hand and knee forwards.

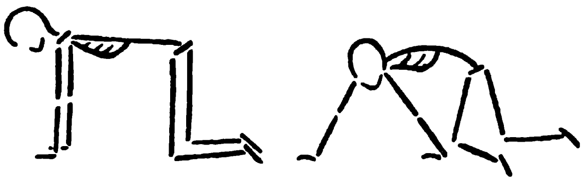


FIG. 81. Dog Crawl

In teaching the exercise it is better to allow the rhythm of the arm and leg movements to become established before re-enforcing the effect by the addition of the head bending and the hip rotation.

Movement to one side only can be produced by a return to the starting position on alternate movements, in which case the patient travels in a circle bending always towards the centre of that circle.

b. *inclined prone kneeling; Low Dog Crawl*

The starting position is taken with the thighs vertical and the arms abducted in line with the shoulders and flexed at the elbows so that the hands rest directly beneath the elbows. The chest is pressed to the ground and expanded and the head well lifted. One knee is moved forward and the spine is bent to this side by lifting or sliding the hands round, the upper arm and shoulders being kept in line. The head

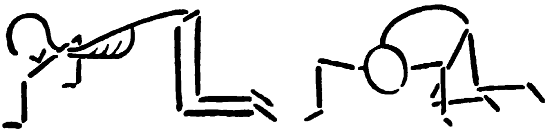


FIG. 82. Low Dog Crawl

is bent sideways as in the previous exercise. Progression is made by moving the other knee forward and swinging round towards it or by a return to the starting position.

Emphasis must be laid on smooth rhythmical movement and on keeping the chest well pressed to the floor throughout. This exercise is strenuous compared with the previous one.

c. *stretch stoop kneeling; Arm Stretch Crawl*

The chest is well pressed to the ground and the thighs remain nearly vertical throughout the movement. The patient moves forward by taking small steps with the knees and sliding the hands forward along the ground, either together or alternately. This crawl is used to increase extension of the thoracic spine and to strengthen the upper back muscles.

FIG. 83. Arm Stretch Crawl

d. *inclined prone kneeling; Leg Lift Crawl*

The starting position is similar to that in Exercise (b) and the effect to that of Exercise (c) but stronger. The movement is as follows:—

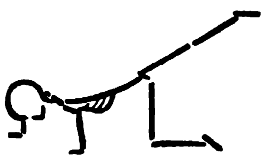


FIG. 84. Leg Lift Crawl

(*i*) one knee is moved forward,

(*ii*) the arms are moved forward from the shoulders,

(*iii*) the other leg is lifted into line with the trunk as the latter moves forward and downward, to bring the shoulders into line with the upper arms once more.

This position is held for a moment and then the leg is lowered and the knee bent and brought forward to repeat (*i*).

e. *inclined prone kneeling; Low S Crawl*

This is designed to straighten the spine in the case of an S-curve scoliosis, by strong contraction of the muscles on the convex side of the curves.

From the starting position—

(*i*) the arm on the side of the concavity of the thoracic curve is

FIG. 85. Low S Crawl

stretched forwards as the leg on the side of the lumbar concavity is stretched backwards.

(*ii*) the thigh of the supporting leg remains vertical throughout, as the patient attempts to stretch the hand and foot as far from each other as possible.

(*iii*) the extended knee is bent and moved forwards, as the opposite hand is returned to the starting position.

(*iv*) a short step forward is taken with the opposite hand and knee.

The movement is then repeated from (*i*).

Once these Crawling Exercises are known, they can be performed to music, carefully chosen to fit the patient's own rhythm. Felt pads must be provided to protect the hands and knees if the exercises are continued for any time or if the floor surface is unsuitable.

PART IV

9

MUSCLE POWER

INTRODUCTION

ACTIVE movement of the skeleton is brought about by the contraction of voluntary muscle. This muscle tissue has contractile properties which are activated by nerve impulses, to supply the effort (or power) required to move or stabilise the body levers.

STRUCTURAL FEATURES

The structural unit of voluntary or skeletal muscle is the muscle fibre (large extrafusal), which is cylindrical in form and averages from 20 to 40 millimetres in length, and $\frac{1}{10}$ to $\frac{1}{100}$ of a millimetre in diameter. It is enclosed in an elastic sheath called the sarcolemma.

Some fibres appear 'red', due to a rich blood supply and the presence of a pigment. Their contraction in response to stimulation is slow, but can be sustained for a considerable time without fatigue. This type of fibre, therefore, predominates in the anti-gravity muscles which are primarily concerned with the maintenance of posture, e.g. Soleus.

Other fibres, paler in colour, and called 'white', respond rapidly to stimulation but are easily fatigued. These form the greater part of muscles which are primarily responsible for movement, e.g. Gastrocnemius.

Muscle fibres, lying parallel to each other, are grouped together and surrounded by connective tissue to form bundles, and many bundles are bound together by denser connective tissue to form the substance of a muscle. Muscles are attached at both extremities to bone, cartilage, or fascia, by fibrous tissue which is continuous with the connective tissue investing the muscle. This fibrous tissue contains elastic non-contractile elements and may be concentrated to form a narrow cord, or spread out to form an aponeurosis.

The more proximal of these attachments, which usually remains relatively fixed when the muscle contracts, is known as the origin, to distinguish it from the insertion, which is the attachment at which the power of contraction is concentrated to produce movement of the body levers. Either attachment, however, may be free to move towards the centre of the muscle, or the insertion may remain relatively fixed and the structure of origin moved, in which case the muscle is said to work with reversed origin and insertion.

The form of a muscle varies according to its function. A wide range and speed of movement is produced by the contraction of long fusiform muscles in which the fibres are all relatively parallel to, or in series with, each other and the tendon of attachment. By this arrangement the number of muscle fibres included is relatively few and limited by the length of the muscle, with the result that no great power can be exerted, as the power of muscle contraction is directly proportional to the number of fibres stimulated. The number of fibres is much increased, in the case of muscles designed primarily for powerful contraction, by the inclusion of fibres arranged obliquely or at right angles to the line of pull of the muscle as a whole. The forces of contraction are compounded at the point of attachment (see p. 2), but the range of movement is obviously limited.

Muscles are supplied by nerves which contain both motor and sensory fibres. Each motor fibre has a cell in the anterior horn of the Spinal Cord or in the nucleus of a Cranial nerve which can be influenced from a variety of sources. The fibre or axon of this lower motor neurone divides on reaching the muscle into from 5 to 150 branches each of which terminates in a motor end-plate beneath the sarcolemma of a muscle fibre. The group of muscle fibres which is supplied by the division of a single nerve fibre is called a motor unit, as impulses conveyed by the nerve fibre will affect them all simultaneously.

A muscle fibre is capable of only one response to stimulation, that of maximum contraction; it is therefore the number of motor units utilised at any one time which determines the intensity or speed of the contraction as a whole.

Sensory receptors, which record the tension of passive stretching, the degree of contraction, pain and deep pressure, are found in muscles and tendons, and impulses recording these are conveyed to the Central Nervous System. The receptors sensitive to stretching of the muscle are component parts of the muscle spindles which lie between and parallel to its fibres. Stimulation of these sensory receptors results in a reflex contraction or relaxation of a particular group of muscles. Other components of the spindles are the small intrafusal muscle fibres, the sustained contraction of which is considered to be responsible for muscle tone upon which the contraction of the large extrafusal fibres responsible for voluntary movement is superimposed. The function of the spindles and their nervous connections also serves to increase the efficiency of motor unit activity. Sensory fibres from receptors in the joints and the fibrous tissue which surrounds them travel in the same nerves which supply the muscles which pass over the joints, and a reflex contraction of these muscles in cases of strain is an important factor in preventing joint injury.

TYPES OF MUSCLE WORK

There is a change in the length of a muscle when it works to produce movement in opposition to an external force, and when it works to resist movement produced by an external force which gradually overcomes it. When the attachments of a working muscle are drawn towards the centre of that muscle, it works concentrically, i.e. towards the centre, or 'in shortening' (Fig. 86). When the attachments are drawn away from the centre, as its resistance is overcome by the external force, the muscle works eccentrically, i.e. away from the centre, or 'in lengthening' (Fig. 87).

There is no alteration in the length of a muscle which works to stabilise a joint, the power of its contraction being exactly equal and opposite to the forces which oppose it. In this case the attachments of the muscle remain stationary and it is said to work statically.

Concentric Muscle Work

Muscles working concentrically become shorter and thicker as their attachments are drawn closer together and joint movement results. A patient doing concentric muscle work performs a movement, and in so doing overcomes some force which offers resistance, such as friction, gravity, manual pressure by the physiotherapist, or some form of mechanical resistance.

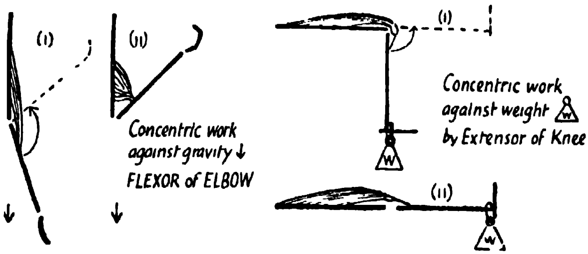


FIG. 86

The physiological cost of this type of work is high, as only about a quarter of the energy liberated during contraction is available as mechanical work. Some is used to overcome the initial inertia and some is converted into heat. Concentric muscle work is used to build up muscle power, and although most everyday movements involve the use of all types of muscle work, it seems to be more natural, and to require least concentration, to use the concentric type.

Eccentric Muscle Work

Muscles working eccentrically become longer and thinner as they pay out and allow their attachments to be drawn apart by the force producing the movement.

The physiological cost of this type of muscle work is low, probably only about a quarter of that required for concentric work, therefore a muscle recovering from paralysis may sometimes be persuaded to contract to resist before it will attempt to produce movement. Considerable concentration is required during exercises designed to work

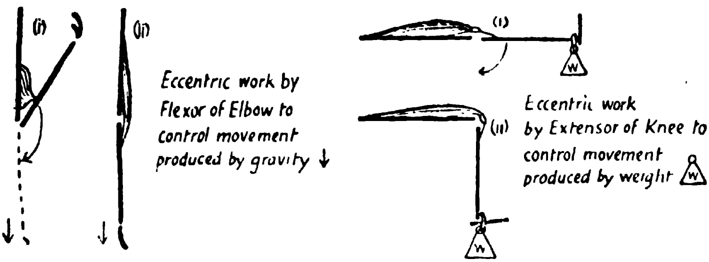


FIG. 87

the muscles in this way. This is probably to control the speed of the movement, as eccentric work in natural movements is usually fairly rapid.

Static Muscle Work

The length of the muscle remains the same throughout the contraction and no movement results.

Static muscle work is more economical than either of the previous types, but it is fatiguing if sustained, probably because of hindrance to the circulation through the muscle, as the result of an increase in the intramuscular tension. Intermittent static contractions are used in the treatment of weak muscles, or when a joint is immobilised, to maintain the tone of the muscles passing over it.

Voluntary static contractions of the postural muscles are used to train the pattern of good posture. Posture is maintained by contractions which are somewhat similar, but are not fatiguing because of the low metabolic rate at which the muscle fibres used contract, and the special nature of their reflex control.

Isotonic and Isometric Contraction

Any active process which results in a change in the length of a muscle, as in the case of prime movers and antagonists, is called isotonic. Muscles which contract while their attachments remain stationary, as in the case of synergists or fixators, are subject to an increase in tension between their attachments, and their contraction is called isometric.

Ranges of Muscle Work

The range of muscle work is the extent of the muscular contraction which results in joint movement.

Full Range

The joint is moved as the muscles work from the position in which they are fully stretched, to the position in which they are fully contracted, concentrically, or, from the position of full contraction, to the position of maximum extension, if they are working eccentrically.

Under ordinary circumstances muscles are rarely required to work in full range, but in emergencies they may have to do so. Active full-range exercises are used for patients as they maintain joint mobility, increase the circulation and ensure that the emergency reserve of power and mobility is preserved.

Inner Range

The muscle works either concentrically from a position in which it is partially contracted (approximately half-way between the limits of full range) to a position of full contraction, or vice versa if it works eccentrically.

Exercise in inner range is used to gain or maintain movement of a joint in the direction of the muscle pull, and to train some extensor muscles responsible for stabilising joints.

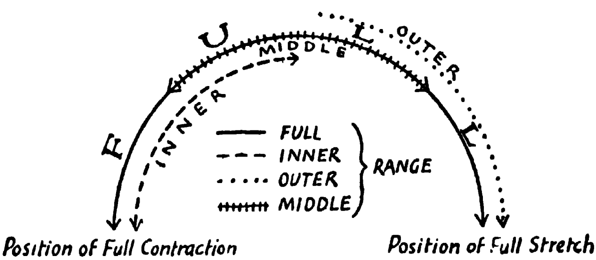


FIG. 88

Outer Range

The muscles work concentrically from the position in which they are fully stretched to a position in which they are partially (half) contracted, or vice versa if working eccentrically.

Work in this range is used to strengthen muscles.

Middle Range

The muscles are never either fully stretched or fully contracted.

This is the range in which muscles are most often used in everyday life and in which, generally speaking, they are most efficient. Exercises in this range maintain muscle tone and normal power, but full joint movement is never achieved.

The Group Action of Muscles

Muscles do not work singly, but in groups, and it is the harmonious working together of several groups which results in co-ordinated movement.

1. The Prime Movers, or Agonists, are the group which bring about the movement by their contraction.
2. The Antagonists, which are the opposing group, relax and lengthen progressively so that the movement is controlled but not impeded.
3. The Synergists are the muscles which work or relax to modify the action of the prime movers. They may alter the direction of pull or, in the case of prime movers which pass over more than one joint, they fix or move the joint in which the main action is not required into the position which is most advantageous.
4. The Fixators are a number of muscles which work to steady the origin of the prime movers or the synergists.

Example. In flexion of the fingers, as in making a fist, the Flexors of the Fingers work as prime movers to perform the movement. The antagonists, the Extensors of the Fingers, relax. The Extensors of the Wrist work as synergists to fix or move the wrist into full extension so that the power of the Flexors of the Fingers, which can also flex this joint, is not diverted to this purpose, but increased as the extended wrist joint acts as a fulcrum for their action.

The appropriate impulses for contraction or relaxation are conveyed to the muscles concerned in any particular movement, from the Central Nervous System. As it is movements, and not individual muscles or even muscle groups, which are represented in the cerebral cortex, the importance of concentrating on the movement rather than on the contraction of a specific muscle or muscle group in re-education cannot be over-emphasised. Furthermore, as the movements which are represented are those to which the patient is accustomed, i.e. natural movements, these are of prime importance.

Two-joint Muscles

Most groups of muscles include at least one which extends across more than one joint. These muscles are most effective in moving one joint when they are stretched over the other, as under these conditions the latter joint is used as a fulcrum and the stretching of the muscle acts as an additional stimulus to contraction.

EXAMPLE. To work the Hamstrings as Flexors of the Knee, the hip joint must flex or be flexed by synergic action; alternatively, to work the Hamstrings as Extensors of the Hip, the knee must extend or be extended during the movement of hip extension.

GROUP MOVEMENT OF JOINTS

Most natural movements involve the use of a series of joints controlled by the integrated action of many muscle groups. The control of these movements may be voluntary and conscious, but in many instances it is unconscious and reflex in character and controlled from the basal ganglia or reflex centres in the spinal cord. The basic patterns seem to be those of thrust, withdrawal, swing and strike.

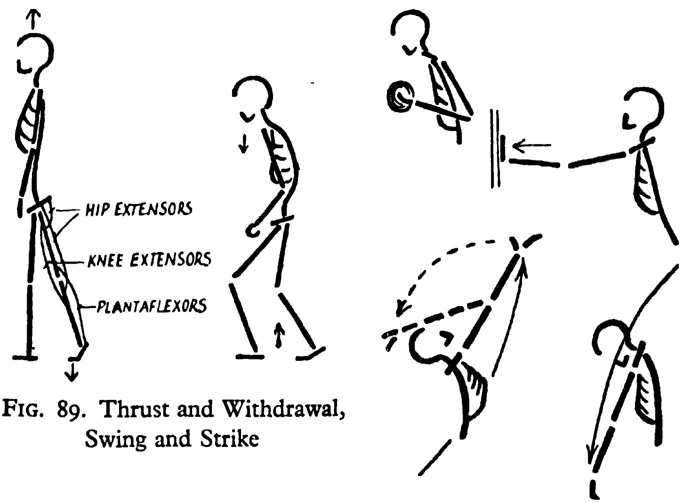


FIG. 89. Thrust and Withdrawal, Swing and Strike

EXAMPLE. In walking, plantaflexion of the ankle joint and extension in the knee and hip result progressively in response to firm pressure on the ball of the foot, but should there be pain in the foot as the result of injury or ill-fitting shoes, a flexion reaction is often imperfectly inhibited to produce a sagging posture and a limping gait.

MUSCULAR WEAKNESS AND LOSS OF POWER

Weakness or loss of power in any muscle or group of muscles not only results in loss of movement or stability of a particular joint, but creates a state of muscular imbalance which affects all the groups concerned in the production of co-ordinated movement. If the weakened muscles are to recover their full function, they must be protected while they are ineffective and encouraged by re-education as they recover, until they are able finally to take their place once more as effective members of the teams of muscles, which work together to perform natural and skilled movements.

Causes of Weakness or Loss of Muscle Power

As contraction is the only means by which muscle power can be maintained or increased, any lesion or habit which prevents or limits contraction will result in loss of power and muscle wasting. Complete loss of power is known as paralysis, partial loss as paresis, or a muscle may be merely weak or sub-normal.

Lesions affecting the Motor Nerves

Damage to the motor pathway, preventing it from conducting impulses essential for contraction, results in paralysis. This interference with the function of the motor nerves may be temporary only, in which case the power of contraction is restored, i.e. neuropraxia, or recovery in muscles affected by poliomyelitis.

Lesions affecting the Muscle Tissue

Degeneration of the muscle tissue results in loss of power which is usually progressive, i.e. muscular dystrophy. Ischaemia causes structural changes, i.e. Volkmann's ischaemic contracture, and extensive scar tissue may replace contractile tissue as the result of deep flesh injuries.

Disuse of Normal Nerve and Muscle Tissue

Loss of power and wasting from disuse is by no means uncommon. A patient may not use his muscles—

a. because he cannot; as contraction is inhibited by pain or other sensory impulses.

b. because he does not need to; joints fixed by splintage are stable and unable to move, therefore there is no necessity for the patient to contract his muscles. It is only when he is instructed and convinced of the necessity of doing so, that he will perform voluntary static contractions to maintain circulation, muscle power and the movement of tendons passing over the temporarily immobilised joints, which are essential for recovery of function when splintage is removed.

c. because he will not; some patients resist all efforts on the part of both doctors and physiotherapists to make them do sufficient muscular contraction to prevent disuse atrophy.

Some Constitutional Diseases

A marked degree of muscle wasting, which cannot be put down entirely to disuse, occurs in some diseases, notably in rheumatoid arthritis.

Functional

There is no organic cause, but the muscles do not function, although they may be forced to contraction by electrical stimulation of the nerve.

THE PREVENTION OF MUSCLE WASTING

In Flaccid Paralysis

Muscles deprived of their motor nerve supply are limp, hypotonic and unable to contract: their condition is known as flaccid paralysis. Rapid wasting takes place and cannot be prevented, although it is thought that it may be arrested by improving the blood supply to the area, and by direct stimulation of the muscle fibres by electrical means.

In Spastic Paralysis

Muscles which receive a motor nerve supply only in response to a spinal reflex, since they are cut off from the higher centres by a lesion affecting the upper motor neurone, are tense, hypertonic and incapable of voluntary contraction or relaxation. This condition is known as spastic paralysis and wasting is not marked.

In Primary Lesions of the Muscle Tissue

In this case loss of power cannot be arrested, although a temporary improvement often follows light exercise in cases which have not previously received treatment. This is probably the result of making the best use of fibres which still function.

In Disuse Atrophy

Disuse atrophy, or wasting, can be prevented or controlled by frequent voluntary contractions. These can be performed in any range possible, or statically, if necessary. The intensity of the contractions and the frequency with which they are practised is directly proportional to the success in maintaining the power and bulk of the muscles. 'Five minutes in every hour with maximum effort' is a good slogan for general purposes. Patients who have difficulty in learning static contractions and in 'finding the muscles' can be helped by faradism in the initial stages. This electrical stimulation of the nerve may also be used to prove to the patient that contraction is possible; but he must also be convinced that it is necessary, to achieve the best results, and regular practice is ensured only when the patient understands the necessity for effort on his part. Comparison of the affected group with healthy muscles on the corresponding limb is often convincing. Patients readily appreciate the difference in shape, feeling of tension and the evidence of measurements of the two limbs, when these are pointed out to them. Coarse muscles, such as Gastrocnemius, Quadriceps, Glutei, and Deltoid, waste very rapidly and therefore require special attention.

The wasting in rheumatoid arthritis, some of which is due to disuse, is combated by active contraction as soon and as often as the condition will allow.

STRENGTHENING METHODS

Contraction is the only means by which the power of muscles can be maintained or improved. The art of training or strengthening muscles lies in creating the conditions under which they are called upon to work to full capacity against an ever-increasing resistance. Increase in strength and hypertrophy occur in response to tension in the muscles set up by the factors which oppose their contraction. It is, therefore, essential that these opposing factors, which constitute the resistance, must be increased as the strength of the muscles improves.

An increase in resistance which is too rapid results in overloading, which prevents contraction or causes damage to the muscles in an attempt to contract. *Underloading will not increase the strength, but may be sufficient to prevent wasting of muscles.*

At the beginning of treatment, assessment of the power of the muscles to be strengthened is obviously essential (see Technique of Resisted Exercises, p. 52). A suitable resistance is then selected, which includes consideration of the poundage of the resisting force, the leverage, the speed, and the duration of the movement. As treatment continues, progression of one or all of these factors is made in step with the development of the power of the muscles. Account must be taken of *all* the work the muscles in question are called upon to do, whether it be Exercises in the Physiotherapy Department, Occupational Therapy, Specific Home Exercises, Work, or the ordinary activities of everyday life.

Muscle training or re-education may be regarded as a continuous process which begins, while the muscles are still paralysed, in the form of an attempted contraction, and extends until maximum function is achieved.

The exact stage in this re-education process at which any particular muscle group begins is determined by the findings at the assessment of power made when treatment begins.

A. Preliminary Treatment and Early Re-education of Flaccid Muscle

While the muscles are still in a state of paralysis they must be cared for and protected from injury, so that their condition will be as good as possible on the day that the impulses essential for contraction are again able to reach them. At the present time this day cannot be estimated with any degree of accuracy and it is only by attempting contraction that it can be discovered. The first flicker of contraction which demonstrates the return of power is indeed an exciting moment for both patient and physiotherapist, which acts as a stimulus to further effort after what may have been months of conscientious work without apparent result.

Principles of Preliminary Treatment and Early Re-education

1. *The Affected Muscles must be protected from prolonged Overstretching by adequate Support and Splintage*

Normal muscles protect themselves from overstretching by a reflex contraction, but those suffering from flaccid paralysis are unable to do so, as they are incapable of contraction; consequently, they may become stretched beyond their physiological limit and injured by the force of gravity or the unopposed action of healthy antagonistic muscles.

EXAMPLE. A lesion affecting the Anterior Tibial Nerve results in a dropped foot, as gravity and the unopposed action of the Calf Muscles plantaflex the foot. To prevent injury to the Anterior Tibial Muscles a splint or toe-spring must be worn until their power of contraction is sufficient to restore muscle balance.

2. *The Circulation to the Area must be maintained to ensure Adequate Nutrition to the Paralysed Muscles by such means as Heat, Massage, and Movement of Neighbouring Joints unaffected by the Paralysis*

The arterial blood flow to muscles is much increased during active work to supply the oxygen and nutrition essential for repair and, at the same time, the local venous return is assisted by the intermittent pressure exerted on the vessels, by the contracting muscles, and by the movement of joints. Paralysis leads to coldness and blueness of the area, indicating poor circulation.

3. *The Mobility of Joints and the Extensibility of the Muscles which pass across them must be maintained by Full-range Passive Movements*

The fibrous tissue which constitutes the sheaths of muscles, ligaments of joints and fascia, undergo adaptive shortening if subjected to prolonged immobilisation. One full-range movement at frequent intervals is sufficient to prevent this and, in practice, two full-range passive movements performed twice daily are found to be adequate.

4. *Remembrance of the Pattern of Movement must be stimulated and kept alive by Passive Movement while Active Movement is impossible*

Movement is associated in the brain with numerous sensory impulses from the joints, muscles, skin and eyes. In the absence of voluntary movement, stimulation of these sensory impulses by passive movement reminds the brain of the pattern of movement, in preparation for the time when the motor pathway will once more be intact.

In this way co-ordinated movement, made possible again by the return of power to the affected muscles, is remembered, and does not require to be re-learnt or re-developed.

The passive movements used for this purpose must obviously follow the natural pattern of movement with regard to the group movement of joints.

5. *The Power and Use of Normal Muscles in the Area must be maintained as far as possible by Active Exercise*

Unless the limb is flail (all muscles paralysed) all possible activity is encouraged, provided overstretching of the paralysed muscles is prevented. Thus wasting from disuse is prevented and circulation to the part is improved.

EXAMPLE. A man with Anterior Tibial paralysis is able to walk about provided he wears a toe-spring, and the advantage of his being able to work is obvious.

6. *Contraction of the Affected Muscles must be discovered and encouraged at the Earliest Possible Moment by creating the Ideal Conditions under which Minimal Contraction will take place*

These conditions, generally speaking, as as follows:

Warmth. The area in which movement is to take place must be warm, as warmth improves the quality of contraction.

Stabilisation. The origin of the working muscles must be stabilised to improve their efficiency.

Resistance. The part moved must be supported, or the force of gravity acting upon it will constitute a resistance which is too great to allow contraction to take place. Other forces such as friction may also have to be cancelled out or reduced.

Range of Muscle Work. The range in which contraction is attempted must be that in which the muscle pull is most efficient, that is, for many groups, somewhere about middle range (p. 117).

Type of Muscle Work. Many find that concentric muscle work can be accomplished first, as it appears to be the most natural type. It is, however, the most expensive with regard to effort, therefore some prefer to try eccentric work first. If efforts to achieve contraction fail with one type, it is worth trying the other (p. 115).

Preliminary Stretching. A slight degree of preliminary stretching of the muscle group in question acts as a stimulus to contraction. Care must be taken to see that stretching is not too great or too prolonged to cause injury to the muscles.

Effort. Conscious effort and remembrance of the pattern of movement must be made by the patient.

Fatigue. No more than a flicker of contraction can be expected at first. A decrease in the quality, of the contraction indicates fatigue.

EXAMPLE. The Preliminary Treatment in the case of injury to the Circumflex Nerve causing flaccid paralysis of Deltoid and resulting in the loss of the power of abduction at the shoulder joint, might be carried out as follows:

(*i*) Support is given by an abduction splint, or a muff and sling.

(*ii*) The circulation to the area is improved by warming the limb by immersion in a whirlpool bath, or by giving the treatment under a radiant heat lamp.

(*iii*) The mobility of the joints and extensibility of the muscles are maintained by two full-range passive movements, given with the shoulder girdle fixed.

(*iv*) Remembrance of the pattern of movement is stimulated by passive elevation of the arm, during which the patient actively elevates the other arm.

(*v*) The power of the normal muscles is maintained by active exercise for the hand, elbow, and shoulder girdle, while the shoulder is supported in abduction.

(*vi*) The contraction of the Abductors is attempted in recumbency with the shoulder girdle fixed, and the arm flexed at the elbow and supported in a degree of lateral rotation. Support for the upper arm

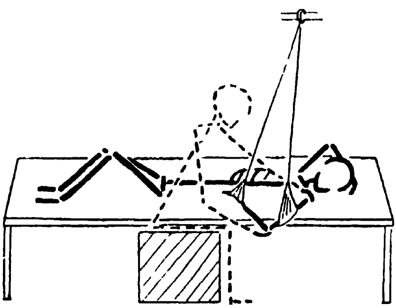


FIG. 90

is horizontal and may be given by a well-polished and powdered re-education board, sling suspension, water, or the physiotherapist's hands.

Assuming that the use of concentric muscle work has been decided upon, a preliminary passive movement of adduction is given to stretch the muscle gently, and then the patient is instructed to concentrate and try to lift the elbow into abduction as the movement is brought back to the middle of the range. A rest follows and the procedure is repeated or eccentric work is tried by asking the patient to try hard to keep the arm from the side as it is partially adducted.

B. Subsequent Treatment to increase Muscular Power and Function

Once the power of contraction has been regained, the muscles are strengthened progressively until maximum function is obtained. Passive movements, support, and artificial methods of assisting the circulation are discontinued gradually and are replaced by active exercise.

Principles of Subsequent Treatment to Increase Power and Function

1. *The Affected Muscles must be Strengthened Progressively by Resisted Exercises, which are Specific for the Group to which the Muscles belong*

These exercises, in which muscular action is localised to the group in question, progress thus:

a. *Range.* The range of movement is increased.

b. *Type of Muscle Work.* Both concentric and eccentric work and finally static contraction are provided.

c. *Resistance.* The resistance is increased by:

(*i*) inclining the plane of movement to increase the effect of the force of gravity upon the part moved;

(*ii*) increasing the poundage of the resistance;

(*iii*) increasing the leverage of the resistance.

d. *Speed.* Increase or decrease in the speed of movement is a progression for concentric work. Decrease in speed is a progression for eccentric work. Lengthening of the contraction period is a progression for static holding.

e. *Duration.* Increase in the number of times an exercise is performed or decrease in the rest period between each series of exercises, or a combination of both according to circumstances, makes more work for the muscles.

2. *Full Function of the Affected Muscles as Members of the Teams of Muscles which Work to produce Skilled and Co-ordinated Movement, must be restored by Free Activities, Natural and Skilled Movements*

Progression of these exercises follows on lines similar to those stated above for resisted exercises. Pendular movements requiring relatively little power are used at first to assist in the restoration of muscle balance, progressing to slow sustained or rapid movements requiring more power. Small-range movements in which many joints must be controlled are the most highly skilled.

Types of Exercises used to strengthen Muscles

All active exercises maintain or increase muscle power. Weak muscles are provided with work suitable to their capacity by the use of Assisted, Free, or Resisted Exercises, while Objective, Recreational or Occupational Activities ensure their return to functional use.

It cannot be over-emphasised that the choice of a particular exercise does not necessarily ensure the desired effect: it is the manner and speed with which the exercise is performed which determines the effect it produces. In general, strengthening exercises are slow and precise.

Assisted Exercises

These are rarely used to strengthen muscles except in cases of marked weakness when their power is insufficient to overcome the resistance of gravity, friction, or the tension of opposing muscles. In practice it is preferable to eliminate gravity by support and reduce friction by the use of a powdered and polished re-education board.

Free Exercises

Free exercises are most valuable as they can be practised at regular and frequent intervals and at home. Careful selection of the starting positions and accurate teaching ensure the use of the muscles in question and grade the exercise to match their capacity for work.

Resisted Exercises

These exercises create the tension in muscles essential for increase in power and hypertrophy. Relative localisation of the affected group helps to restore the balance of muscle power more rapidly and so prevent trick movement and strain elsewhere.

Activities

These are essential to ensure integrated action of muscle groups in the production of movement. They also restore confidence and general health.

Measurement of Progress

The only sure method of measuring progress lies in estimating the return of function, as the muscles work to produce co-ordinated movement and joint stability.

Increase in bulk and in power of contraction, when the action of the muscles is localised, are related to returning function, but do not necessarily presuppose it. Bulk can be measured by the use of a tape measure round the circumference of a limb at a specific level. Power can be measured by recording the poundage of a resistance moved under standard conditions.

EXAMPLE. The bulk of the Knee Extensors may be estimated by measurement round the circumference of the thigh at a level 2 inches and 5 inches above the base of the patella. The power is measured by means of the static or dynamic tests (p. 52) but real test of progress is the patient's ability to use the muscles to walk or climb stairs correctly.

10

TECHNIQUE OF STRENGTHENING MUSCLE

THE MUSCLES OF THE FOOT

THE action of the foot muscles is to stabilise it to support the body weight, and to provide the power essential for its use as a lever to propel the body forwards.

THE INTRINSIC MUSCLES

Lack of power in these muscles produces a dropped transverse arch, buckling of the toes, and Hallux Valgus. To restore the state of muscle balance, the weak muscles must be exercised to produce two movements.

(*i*) *Flexion of the Metatarsophalangeal Joint, combined with Extension of the Interphalangeal Joints.*

This restores the position of the transverse arch and straightens the toes by using the Interossei, Lumbricals, Adductor Hallucis, Flexors Hallucis and Minimi Brevis, and so balances the action of the Long Flexors (and Flexor Digitorum Brevis) which buckle the toes when their action is unopposed.

(*ii*) *Toe Abduction and Adduction.*

The Dorsal Interossei, Abductor Hallucis and Abductor Minimi Digiti part the toes from the mid-line of the foot and extend them. The Plantar Interossei and Adductor Hallucis draw the toes together and flex them.

Flexor Digitorum Brevis and Flexor Accessorius are associated with the Long Flexors, and help to arch the sole of the foot so that the skin is wrinkled. Extensor Digitorum Brevis works only with the Long Extensor of the toes.

Assisted Exercise for the Intrinsic Muscles. As many people are far from foot conscious, it is often necessary to use manual assistance to give the patient the feeling of the movement, or faradic stimulation to help in 'finding' the muscles, and so convince him of his ability to contract them.

Examples of Free Exercises for the Intrinsic Muscles. At first these are non-weight-bearing progressing to weight-bearing. Any exercise which produces buckling of the toes, i.e. extension at the metatarso-phalangeal joints with flexion at the interphalangeal joints, must be avoided. The balanced action of the Intrinsic Muscles with that of the Long Flexors, as in the push off from the toes in walking, is taught and practised until the normal reflex is re-established.

a. *sitting (Toes resting on a book); Toe flexion and extension at the metatarsophalangeal joint with pressure on the balls of the Toe* (see Ex. (g), Para. 3, p. 78).

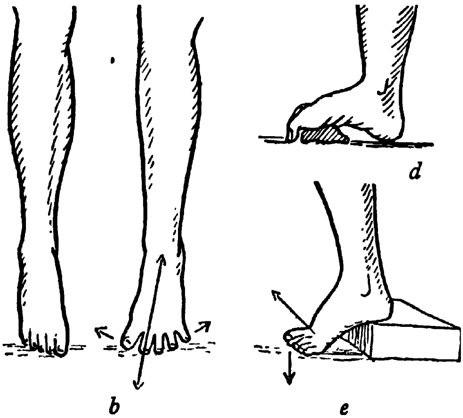


FIG. 91

b. *sitting; Toe spreading.*

c. *sitting; Foot arching.*

d. *sitting; moulding Foot round beanbag or ball to lift it.*

e. *standing (Heel raised and supported); same movement as* (a) *to train push off from Toes.*

Resisted Exercise for the Intrinsic Muscles. The movements can be localised and resisted manually by the physiotherapist.

Activities. The use of the muscles in walking, jumping and running must be trained and practised. A mirror is of great value until the patient becomes foot conscious and able to appreciate the feel of the movement.

THE DORSIFLEXORS

Full-range contraction of these muscles is only possible with the knee bent, as tension of the Calf Muscles limits the range when the knee is straight.

Assisted Exercise for the Dorsiflexors. From *side lying, with the knee bent,* assistance can be given with the hands. If a sitting position is used the knee must again be bent, and a suitable grasp for the physiotherapist is round the heel, so that the foot rests on her forearm, while the other hand fixes the lower leg and palpates the muscles during contraction.

Mechanical assistance can be arranged with a pulley and weight.

Examples of Free Exercises for the Dorsiflexors. Full-range work is made possible by bending the knee, but as the power of the muscles increases, the opposition created by tension of the Calf Muscles when the knee is extended leads to a stronger contraction. This combination of movements is used as the leg swings forward in walking.

a. *sitting leg crossed; one Foot dorsiflexion and slow plantaflexion* (see Fig. 54*a*, p. 77).

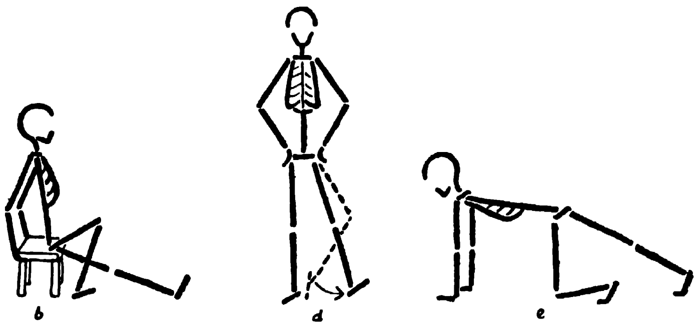


FIG. 92

b. *inclined long sitting; Leg flexion and Ankle dorsiflexion.*
c. *long sitting; Ankle dorsiflexion, alternately.*
d. *half standing; Heel placing.* This exercise can be done in any direction with or without hopping on the other foot (Jig or Reel).
e. *prone kneeling; one Foot dorsiflexion,* with or without Leg movement.

Examples of Resisted Exercise for the Dorsiflexors. Manual resistance can be given (for suitable grip see Fig. 97, p. 133). The action of Extensor Hallucis can be emphasised by resistance given on the

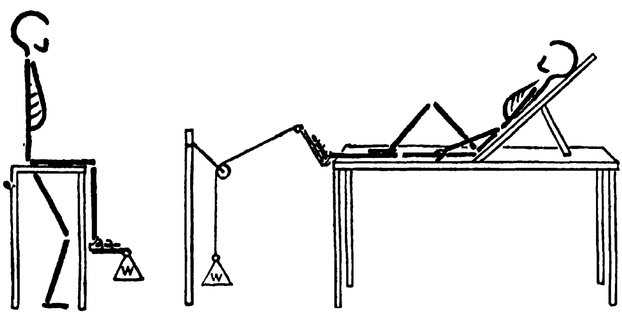


FIG. 93

dorsum of the big toe, that of Extensor Digitorum Longus (and Brevis) by resistance on the dorsum of the toes. Tibialis Anterior contracts most strongly when dorsiflexion and inversion are resisted. Resistance can also be arranged by using weights, pulley and weight, and springs. An elongated sole, firmly and comfortably attached over the patient's shoe, provides additional leverage for the resistance, and a suitable means of attachment.

Activities. Walking,.walking uphill and climbing, bicycling (with pedal straps), walking on all fours, and long jump are all activities in which these muscles are used.

THE PLANTAFLEXORS

These muscles are powerful as they propel the body forwards and help to stabilise the foot and ankle. With the exception of Soleus they all work across more than one joint, and because of this, the Long Flexors of the toes are most capable in this capacity when the metatarsophalangeal joint is extended. Gastrocnemius is most efficient when the knee is extended, while the function of Soleus is mainly postural to steady the leg on the foot. Tibialis Anterior is primarily an invertor, and supports the longitudinal arch of the foot, but it can assist dorsiflexion.

Assisted Exercise for the Plantaflexors. Gravity is eliminated when these muscles work with the leg supported medially or laterally in the horizontal position; with the knee extended assistance can be given manually in any non-weight-bearing position.

Examples of Free Exercises for the Plantaflexors

Non-weight-bearing

a. *long sitting or half standing* } *(Heels free); Toe pointing, alternately.*
b. *prone lying (Feet over end of plinth); Toe pointing, alternately.*
c. *sitting; Heel raising.*

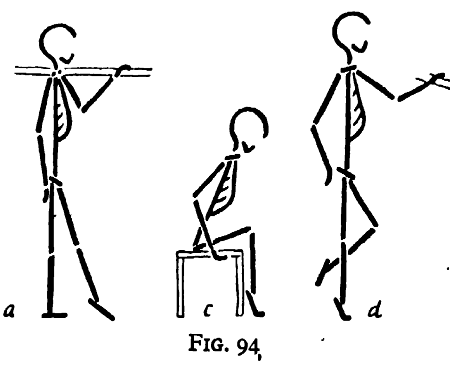


FIG. 94

Weight-bearing

d. *half standing; one Heel raising* (Fig. 94*d*).
e. *reach grasp high standing; Heel raising and slowly lowering.*
f. *standing; 'Bob' jump, hopping or dancing steps.*

Resisted Exercise for the Plantaflexors. Manual resistance can be offered to the muscles with the patient in positions such as *long sitting* or *prone lying* (*with knees bent*), care being taken to see that resistance is given on a sufficient area of the sole to avoid straining the intertarsal joints and plantar structures. The action of the Long Flexors can be localised by fixing the ankle joint in dorsiflexion and resisting under the toes.

Mechanical and auto-resistance is given by a treadle machine or it can be arranged thus—

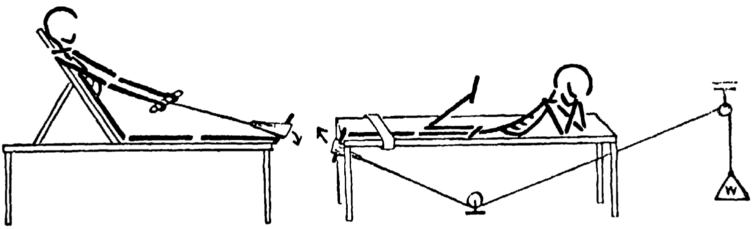


FIG. 95

Activities. Suitable activities include walking, running, jumping, balance walk sideways or up an incline, cycling and rowing.

THE INVERTORS

These muscles rotate the foot inwards, chiefly at the transverse tarsal and subtaloid joints, and maintain the longitudinal arch of the foot, in addition to assisting movements of the ankle joint.

Assisted Exercise for the Invertors. With the patient in *long sitting* or *half lying*, the physiotherapist gives manual assistance by fixing with one hand above the ankle and the other grasping round the heel with the sole of the foot resting on the forearm. Movement then occurs round a vertical axis and gravity is eliminated. Alternatively, a swing board can be used by the patient, the slope of the board on which the foot rests being altered by pulling on the ropes.

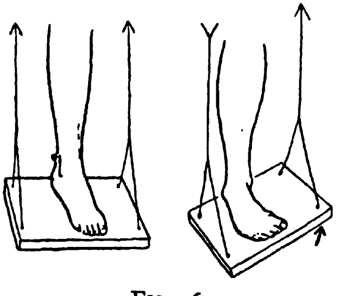


FIG. 96

Examples of Free Exercises for the Invertors

Non-weight-bearing

a. *sitting; inner border raising.*
b. *long sitting; turn soles of Feet to face each other.*
c. *sitting; brush stockings, or sand, into pile between Feet* (lower leg must be kept vertical).
d. *sitting; pick up beanbag between Feet, or with one Foot, and pass it to opposite Hand.*

Weight-bearing

e. *standing; brace longitudinal arch.* The ball of the great toe must remain on the ground; the movement is assisted by rotating the leg laterally so that the patellae look outwards.
f. *standing; balance on inclined surface, such as see-saw rocker, or inclined form.*

FIG. 97

Resisted Exercise for the Invertors. Manual resistance can be given with a clasp grasp with the patient in *half lying.* Mechanical resistance can also be arranged, but free exercises with weight-bearing are usually more satisfactory.

Activities. Walking, running, or balancing on uneven ground, and kicking a football are activities in which these muscles work strongly.

THE EVERTORS

In the non-weight-bearing position Peroneus Longus and Brevis evert the foot and assist plantaflexion, while Peroneus Tertius, if present, assists eversion and dorsiflexion. In the weight-bearing position Peroneus Longus depresses the ball of the great toe, and enables the foot to remain plantagrade while the medial arch is maintained by the invertors.

Assisted Exercise for the Evertors. These are performed in a manner similar to that used for the invertors.

Examples of Free Exercises for the Evertors

Non-weight-bearing

a. *sitting; outer border raising.*
b. *sitting; brushing movement outwards.*

Weight-bearing

c. *standing; pressing ball of great toe to ground and raising outer border of Foot.*

d. *standing, or Toe standing; balance on surface which slopes downwards and medialwards.*

Resisted Exercise for the Evertors. Resistance can be given by manual pressure on the lateral side of the foot. Weight resistance can be arranged in *side lying.*

Activities. Walking on uneven ground and tiptoe walking.

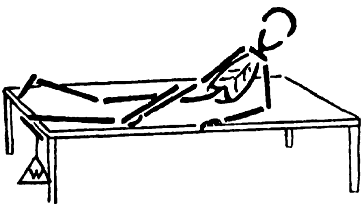


FIG. 98

The action of all the previous muscles groups are combined in exercises such as Foot rolling, which can be performed with emphasis on the movement produced by any particular group or muscle.

THE KNEE EXTENSORS

The Quadriceps Muscles extend the knee joint and are of prime importance in maintaining its stability. The texture of these muscles is coarse and they waste rapidly if they are not used. In addition to its function as an extensor of the knee, Rectus Femoris assists flexion of the hip joint and the action of Vastus Medialis is essential for the production of the last few degrees of knee extension and for the medial rotation of the femur on the tibia which constitutes the 'screw home', or locking movement at the completion of this movement.

Assisted Exercise for the Knee Extensors. A suitable position for the patient is *side lying* with the leg supported or suspended in the horizontal position to eliminate the effect of gravity on the joint. The thigh is fixed with the hip in extension, to remove tension from the

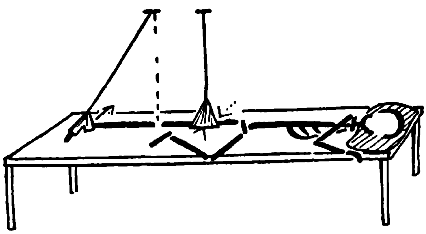


FIG. 99

Hamstrings and obtain the advantage of slight tension on the Rectus Femoris as it passes across the front of the hip. Spring recoil or a weight and pulley circuit may be used to reduce the effect of gravity in the *lying* or *half lying* positions, but their use requires much skill and care.

Examples of Free Exercise for the Knee Extensors

Non-weight-bearing

a. *lying; static Quadriceps contraction (or setting).*

Three methods which may be used to obtain this contraction are:—

(*i*) The contraction is taught on the unaffected leg and is seen and felt by the patient, who then attempts a similar contraction on the other leg.

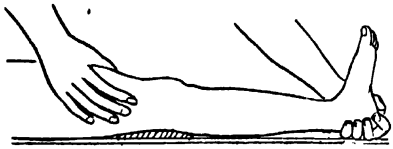


FIG. 100. Quadriceps Contraction (iii)

(*ii*) A hand is placed behind the knee and the patient is instructed to press the back of the knee on to this hand and down to the plinth.

(*iii*) The physiotherapist puts one hand on the muscles and the other under the patient's heel; the patient is then asked to feel the pressure on the heel and attempt to relieve it by lifting the leg. No movement takes place, but the muscles are thrown into a state of strong contraction.

In every case the Quadriceps contractions are reinforced by strong dorsiflexion of the ankle joint and inversion of the foot. When effusion

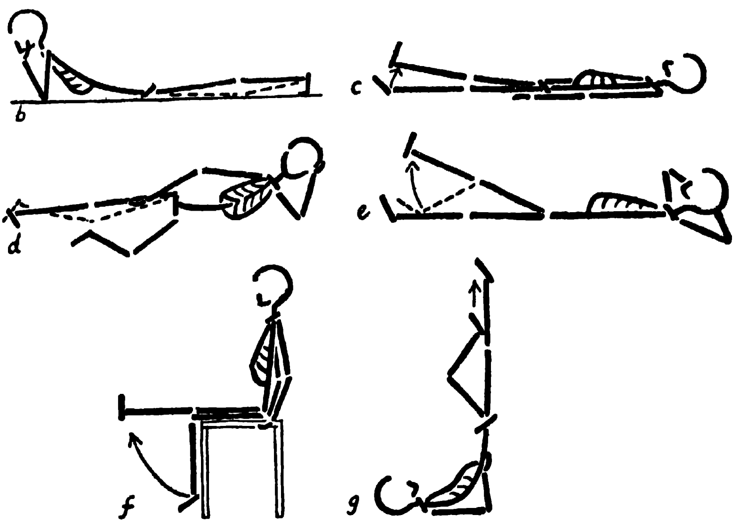


FIG. 101.

is present only non-weight-bearing exercises are used and only a small range of flexion, if any, is allowed.

b. *prone lying (Feet dorsiflexed); Knee extension* (Fig. 101).
c. *lying; Quadriceps contractions followed by one straight Leg lifting and lowering, slowly.* The leg must not be lifted too high because increasing tension on the Hamstrings will force it to bend.
d. *side lying; one Hip and Knee bending and stretching.*
e. *lying; one Hip and Knee bending, Knee stretching and leg lowering.*
f. *high sitting; Knee stretching.*
g. *lying (with Hips lifted); Hip and Knee bending and stretching.* This is only suitable for the young and agile.

Partial Weight-bearing

h. *prone kneeling; Knee stretching.*
i. *heave grasp standing; Knee bending and stretching.* Part of the weight is taken on the arms throughout.

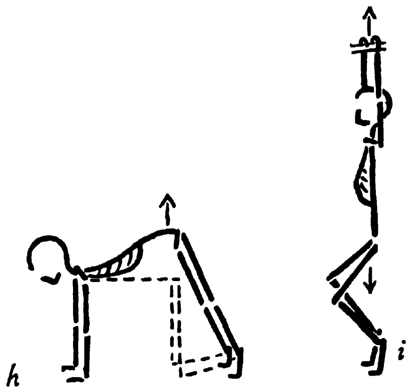


FIG. 102

Weight-bearing

j. *Back against standing; Knee bending and stretching.*
k. *fallout standing; push off to standing.*
l. *standing; step up and down.*
m. *Toe standing; 'bob' or 'stride' jump.*
n. *Toe standing; step and hop, with bent or straight Knee.*

Examples of Resisted Exercise for the Knee Extensors. Manual resistance can be given in a variety of positions including *half lying, high sitting* and *prone lying*. The natural thrusting movement of the leg as a whole is resisted in *lying; single Leg outstretching* (see Swedish Remedial Exercises, No. 6, p. 189), and in *Knee sitting; Trunk raising and downpressing* (No. 7, p. 190).

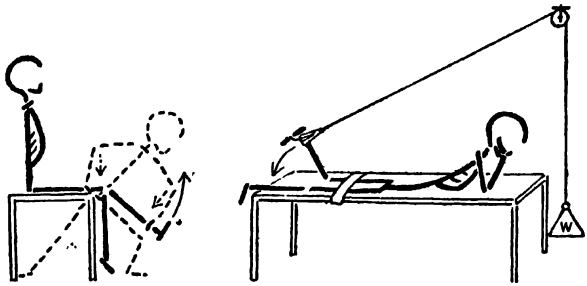
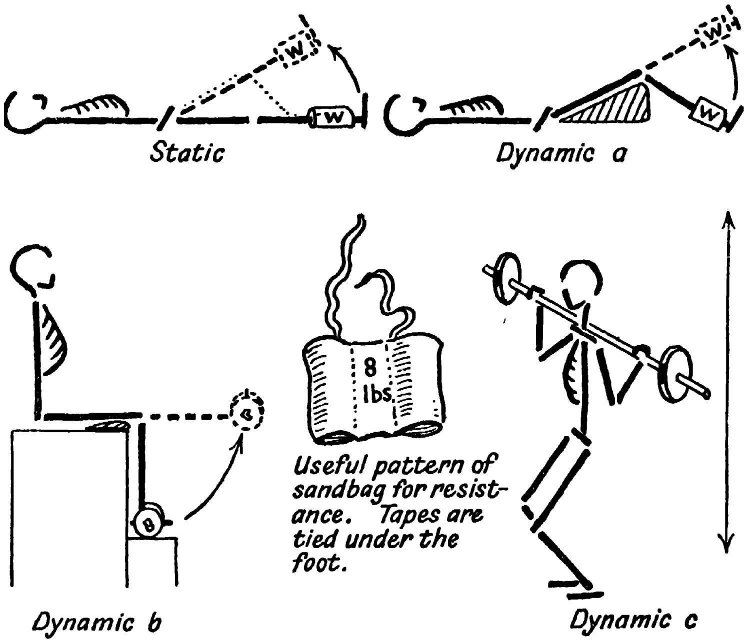


FIG. 103



Weight-lifting methods

FIG. 104. Resisted Exercise for Knee Extension.

The patient may resist his own knee extension by the use of the weight or pressure of the contralateral limb when the ankles are crossed (see p. 47) or weights and pulleys may be arranged in a variety of ways (see p. 50). Springs are useful in some positions or a medicine ball may be held between the feet or thrown by them during knee extension from *high sitting*.

Heavy Resistance Exercises (see p. 49) are often used to increase the power and endurance of the Knee Extensors. Methods of applying these exercises vary considerably but in every case it appears that the selection of the starting position and the rate of progression are important factors to be considered at each successive stage of treatment. A precise but flexible routine must be designed to meet the capabilities of the individual patient and his efforts must be carefully observed. Some suggestions as to suitable positions and methods are as follows:—

(*i*) Static Weight Lifting. Static muscle work is used while effusion is present or when the condition of the joint contraindicates movement. From *half crook lying* or *inclined lying* the muscles are first contracted to take the strain of the resisting force, the leg is then lifted with the knee fully extended until it is in line with the thigh of the crooked leg and then lowered to the floor and relaxed before the procedure is repeated. An endurance programme is usually most suitable, working on the basis of a 10 R.M. with increase in repetitions to the maximum of 100 before re-assessment.

(*ii*) Dynamic Weight Lifting A. From *crook lying* (*with the thigh firmly supported*) the lower leg is fully extended and then lowered to the floor. Exercise in this position provides a useful intermediate stage between that of static work and the method by which the de Lorme boot is lifted in *high sitting*, as the latter position imposes considerable strain on the anterior structures of the joint when the leg is bent to a right angle. Contraction of the muscles involving movement of a joint is normally used only when effusion has subsided but in many cases the presence of chronic or minimal swelling may be ignored unless it is increased by exercise. A power programme is usually introduced at this stage.

(*iii*) Dynamic Weight Lifting B. From *high sitting*, with a small pillow under the popliteal space, the knee is fully extended to lift the de Lorme boot and then lowered. The movement must be smooth and controlled throughout; the boot may rest on a support between each lift or only between each group of repetitions.

(*iv*) Dynamic Weight Lifting C. The bar-bell is held supported across the back of the shoulders while the knees are fully bent and stretched for the required number of repetitions. The back is held erect throughout the movement. If the calf muscles are shortened a small lift under the heels may be provided. This method provides strong work for the Knee Extensors within the framework of the normal thrusting pattern of movement of the lower limbs and it must therefore be regarded as very satisfactory.

Examples of Activities to use the Knee Extensors. These are very numerous. In non-weight-bearing positions such as *high sitting* and *crook sitting* beanbags and balls can be balanced on the feet and thrown by a rapid extension of one or both knees. Bicycling, breast-stroke swimming, rope climbing and rowing with a sliding seat all give good exercise to these muscles.

During weight-bearing, walking up and down hills or stairs, running, jumping, skipping, lifting heavy weights using the knees, and balance walking with knee bending and stretching, while a weight is carried in the hands, are examples. Care must be taken to ensure rhythmical and even movement and to see that full advantage is taken of the extensor thrust.

THE KNEE FLEXORS

The Hamstrings (Biceps Femoris, Semitendinosus and Semimembranosus) are the most important Flexors of the Knee, and, as they also extend the hip, they can be strengthened by producing this movement when the knee is extended. Assistance in flexing the knee is given to the Hamstrings by Sartorius, Gracilis and Popliteus, and when the foot is on the ground Gastrocnemius and Plantaris also help.

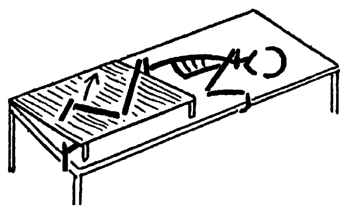


FIG. 105

Assisted Exercise for the Knee Flexors. In *side lying* the leg is supported or suspended in the horizontal position with the hip joint flexed, the thigh is then fixed and knee flexion is assisted manually. A re-education board slightly inclined can also be used, provided the frictional resistance it offers is sufficient to prevent knee flexion occurring passively.

Examples of Free Exercises to work the Knee Flexors

a. *side lying; one Hip and Knee bending.*
b. *hanging; Knee bending.*
c. *standing; one Hip and Knee bending.*
d. *inclined prone lying; Knee bending and stretching slowly.*
e. *crouch position; crouch 'Bunny' jump, or Feet changing by leaping.*

Resisted Exercise for the Knee Flexors. Side lying, with the leg supported and the hip flexed, and *prone lying* are convenient positions for manual resistance. *Heave grasp lying; Leg updrawing and downdrawing* (see Swedish Remedial Exercises, No. 4, p. 187) works the muscles and follows the natural movement of withdrawal. A weight resistance

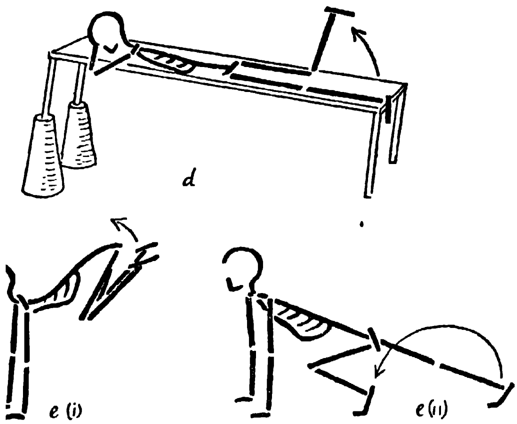


FIG. 106

on the foot can be applied in *half standing* or *prone lying*, in the latter case the muscles only work in their outer range.

Spring or weight and pulleys can be used in *side lying* with the leg supported, *prone or crook half lying*.

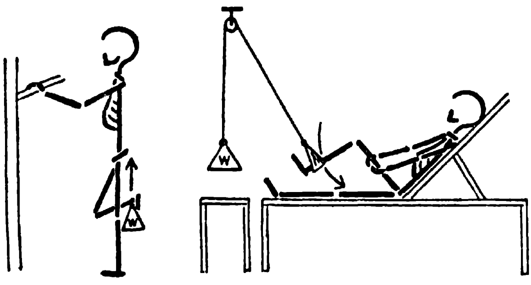


FIG. 107

Activities. These muscles are used in walking and running, and in any upward jump in which the feet are lifted high with the knees bent, as for example squat vaults and forward jump over a rope.

THE MUSCLES ROUND THE HIP JOINT

In many conditions producing pain in this joint, the latter is held in a position of flexion, adduction and lateral rotation. It is, therefore, often essential to exercise the Hip Extensors, Abductors and Medial Rotators to counteract the tendency to deformity. In mid-thigh amputations, when the Hamstrings and some of the Adductors are cut, the remaining Extensors and Adductors must be hypertrophied to restore the balance of muscle power which is essential for the correct usage of an artificial limb.

THE HIP EXTENSORS

Acting from above, these muscles extend the flexed hip until the leg is in line with the body and then about 15° beyond this, until movement is stopped by the tension of the Flexors and the ilio-femoral ligament. When they work with reversed origin and insertion, the pelvis is tilted backwards on the femoral heads, as in raising the trunk from the stooping position. Gluteus Maximus is regarded as the true antagonist of the Flexors; it is assisted by the Hamstrings whenever strong resistance is offered, the latter being most effective when the knee is straight.

Assisted Exercise for the Hip Extensors. Side lying is the neutral position from which to work these muscles. Manual assistance is the most effective with or without the limb supported in suspension, in water, or on a re-education board. In each case the pelvis can be relatively well fixed by positioning the other leg in full flexion.

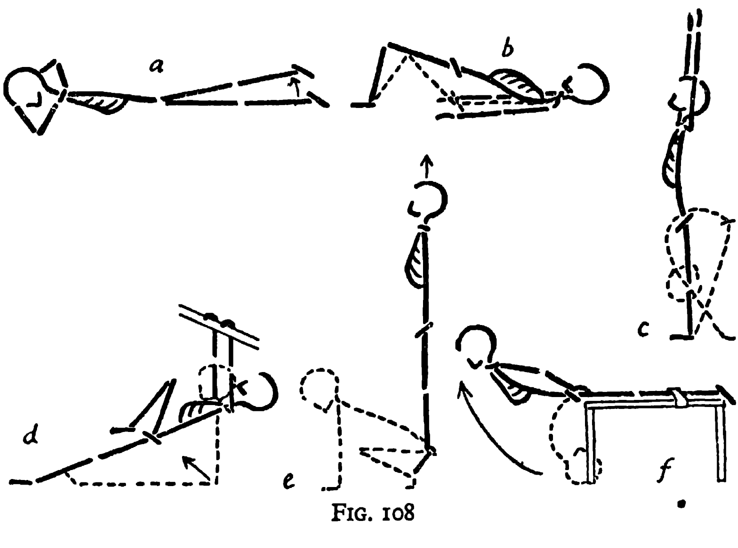


FIG. 108

Examples of Free Exercises for the Hip Extensors

a. *prone lying or standing; one Leg lifting.*
b. *crook lying; Gluteal contraction, and Pelvis lifting.*
c. *relaxed stoop stride standing; Trunk raising.*

d. *stretch grasp long sitting; Hip raising to fall hanging.*
e. *crouch; change to standing (or upward jump).*
f. *Leg prone lying; Trunk raising.*

Resisted Exercise for the Hip Extensors. Resistance to these muscles can be offered in a number of ways according to the range of work required.

For manual resistance, when the leg is moved, the leverage is varied by the position of the hand on the leg, the resistance being greatest when this hand is at the ankle. *Prone lying* or *side lying* are convenient positions for the patient and the knee can either be bent or straight: the former reduces the leverage but renders the Hamstrings relatively ineffective. Movement of the trunk is resisted from *stoop high ride* or *stoop stride sitting.* Other methods of giving manual resistance are fully described in Swedish Remedial Exercises, No. 5, *Single Leg forward drawing and backward carrying,* No. 6, *Single Leg outstretching,* and No. 7, *Knee sitting; Trunk raising and downpressing* (see p. 190).

A simple and effective method of giving weight resistance is from *stoop standing (with Trunk support)* with a weight attached to the foot or a medicine ball held between the feet.

Spring or weight and pulley resistance can also be arranged in many ways, for example, from *lying* the leg is extended against a spring resistance, or a weight and pulley circuit resists extension of the leg as a whole, during a thrusting movement, or of the hip only, from *sitting.*

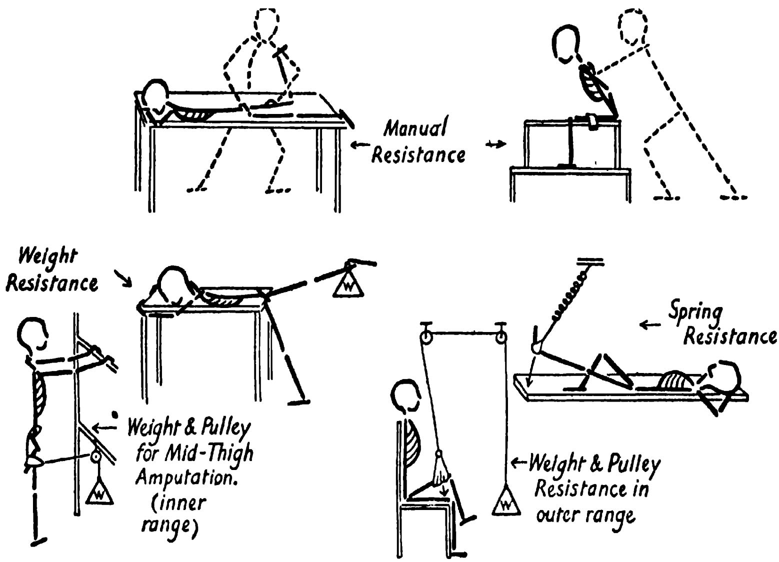


FIG. 109

Activities which involve Work for the Hip Extensors. These are numerous also and include walking, running, especially uphill, jumping and many other forms of athletics, putting the weight, skipping, swimming, ballroom dancing, lifting, pushing and rowing.

THE HIP FLEXORS

The Hip Flexors are Psoas Major and Iliacus, assisted by Pectineus Rectus Femoris (long head) and Sartorius, the latter being most effective when both the hip and the knee are flexed simultaneously. The Adductor Muscles can also assist flexion when strong resistance is offered.

The work of these muscles is usually associated with that of the Lumbar Flexors (the straight Abdominal Muscles). When both legs are flexed on the trunk, the action of Psoas and Iliacus tends to extend the lumbar spine and tilt the pelvis forward as the result of imperfect fixation of their origins, therefore to increase their efficiency the Flexors of the Lumbar Spine work strongly to stabilise the lumbar spine and the pelvis. As flexion of the hip joints continues the Flexors of the Lumbar Spine are assisted by tension of the Hamstrings which tilt the pelvis backwards and consequently help to flex the lumbar spine.

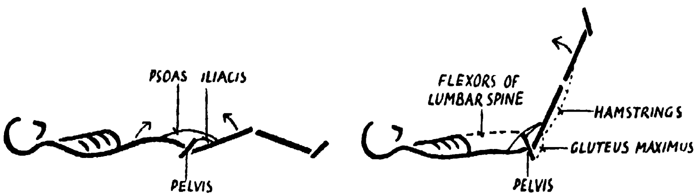


FIG. 110

Arching of the lumbar spine due to failure to fix the origins of Psoas and Iliacus at the beginning of hip flexion.

Fixation of the origins of Psoas and Iliacus by the action of the straight Abdominal Muscles and by tension of the Hamstrings. The latter is greater when the knees are straight.

When only one hip is flexed, the pelvis can be stabilised throughout the movement by the Extensors of the other Hip.

Movement of the pelvis and trunk on the thighs, as in changing from *lying* to *sitting*, also works these muscles strongly, and arching (extension) of the lumbar spine at the beginning of the movement will again occur unless it is controlled by the use of the Lumbar Flexors.

Assisted Exercise for the Hip Flexors. Side lying or *crook lying* are suitable positions from which to assist the movement manually, the lumbar region and pelvic tilt being controlled by the action of the straight Abdominal Muscles, or by flexion of the other hip. Flexion of the knee of the moving leg at the same time as that of the hip makes inner range work possible and the movement then follows the natural pattern. Mechanical assistance can be arranged with springs, weights and pulleys or a roller skate tied to the foot. Self-assistance can also be given when the patient clasps his hands under the thigh.

Examples of Free Exercise for the Hip Flexors

a. *Leg lift lying; one or both Hip and Knee bending.*
b. *lying or crook lying; change to crook sitting.*
c. *prone kneeling; one Hip and Knee bending (to put Head on Knee).*
d. *standing; one Hip and Knee bending (to pass beanbag under thigh).*
e. *hanging; one or both Hip and Knee bending upward.*
f. *long sitting; Leg lifting (to roll football below Knees).*

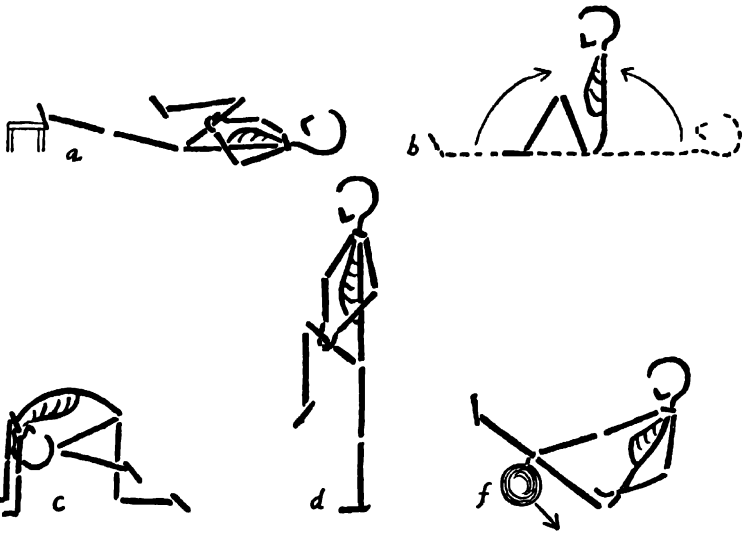


FIG. 111

Resisted Exercise for the Hip Flexors. Strong resistance to hip flexion is offered by gravity in the upright position especially when the knee is straight, as the muscles work at a considerable mechanical disadvantage and against the growing tension of the Hamstrings as flexion increases.

Manual resistance is fully described in Swedish Remedial Exercises, Nos. 2, 3 and 4, pp. 185–7.

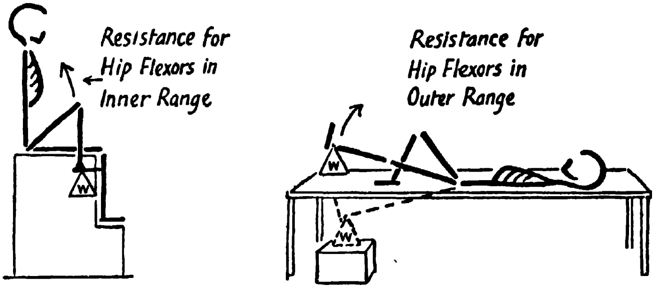


FIG. 112

Mechanical resistance is not often required but can be arranged by attaching a weight or other resistance to the foot from *half lying*, *lying* or *half sitting*.

Activities. Running with high knee bending, long and forward jump over a rope, 'Double Through' skipping, climbing, somersaults and squat vaults work the Hip Flexors strongly in conjunction with the Abdominal Muscles.

THE HIP ABDUCTORS

Working from their origin on the hip bones, these muscles (Gluteus Medius, Minimus and Tensor Fascia Lata) abduct each leg to about 30°. When one leg is fixed and the other abducted, an apparent increase in range of the abducted leg is produced by lateral tilting of the pelvis at the hip joint of the fixed leg by the Abductors of that Hip

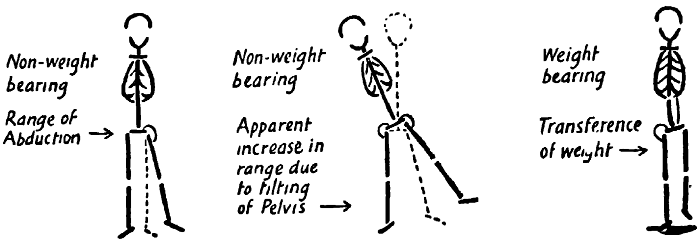


FIG. 113

joint working with reversed origin and insertion. To transfer the whole weight of the body on to one leg as in walking, the Abductors of the Hip of the standing leg work with reversed origin and insertion to tilt the pelvis laterally, while the trunk is kept upright by the Lumbar Side Flexors on the opposite side.

Assisted Exercise for the Hip Abductors. Support or suspension of the moving leg in the horizontal position eliminates the effect of gravity and so assists the muscles. Both legs can be moved simultaneously in the *prone* or *supine position* (*Leg parting*) and the leverage is reduced by flexion of the knees When one leg only is moved, fixation is achieved by abducting the other leg fully.

Manual assistance is given in *lying, half lying* or *side lying*, with grasps similar to these used for passive movements, the knee may be flexed and the lower leg supported.

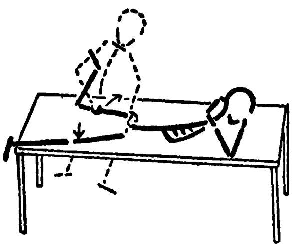


FIG. 114

Examples of Free Exercise for the Hip Abductors

a. *lying, prone lying or hanging; Leg parting.*
b. *lying or high half standing; Leg shortening and lengthening.*
c. *half standing; one Leg lifting sideways.*
d. *side falling; one Leg lifting.*
e. *half yard grasp high half standing; change to star position.*

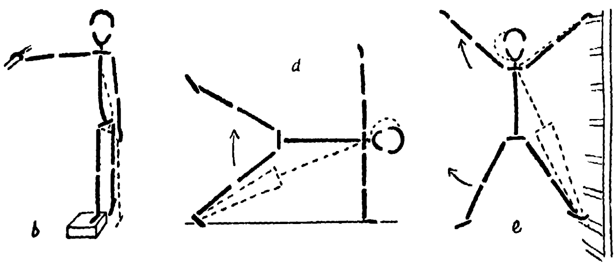


FIG. 115

Resisted Exercise for the Hip Abductors. As the small degree of abduction required to produce a lateral tilt of the pelvis on the standing leg during transference of weight is of major importance, the pattern of this movement must be emphasised. Manual or mechanical resistance to *Leg shortening*, in order to work the Abductors of the Hip of the stationary leg, is easily arranged by fixing one foot and resisting the movement on the other. Note that the muscles of the hip on the side of the fixed foot work with the Lumbar Side Flexors on the opposite side.

Resistance to the movement of the leg on the pelvis is given in *prone*

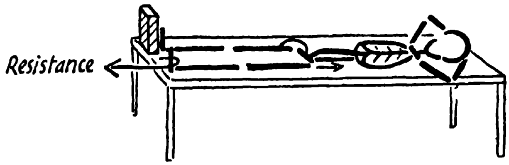


FIG. 116

or *supine lying* with the leg in suspension, the resistance being arranged horizontally. Weight resistance is given in *half standing*, or in *side lying* with either a long or a short lever.

Activities. Breast-stroke swimming, overarm bowling at cricket, leapfrog, walking and running exercise these muscles.

THE HIP ADDUCTORS

These muscles (Adductores Magnus, Longus and Brevis, assisted by Pectineus and Gracilis) form a powerful group; they are frequently subject to adaptive shortening but are comparatively rarely weakened in relation to the opposing group, except as the result of mid-thigh amputation. Their action is thought to be associated with that of the Muscles of the Pelvic Floor.

Assisted Exercise for the Hip Adductors. When both hips are adducted simultaneously from the non-weight-bearing positions the pelvis is fixed, but it is remarkably difficult to control substitution of a lateral tilt and side flexion of the lumbar spine when only one leg is moved. *Lying*, with the spine fully flexed to the side opposite to that of the moving leg, is suggested as a means of localising the movement to the hip joint, and it also permits a wide range of pure adduction. Inner range work with the hip in extension is usually limited by contact with the other leg, but when the hip is flexed a wider range is obtained by crossing the thighs.

Manual assistance can be given for one or both legs with gravity eliminated in *lying* or *prone lying*, with or without the limbs being supported by suspension or water. In *lying* also, provided the frictional resistance is sufficient to prevent the movement occurring passively, a re-education board under the leg, tilted downwards and medially, reduces the work of the muscles. In *prone lying*, the leverage is reduced by flexion of the knee. For grasp used in this case see Fig. 114, p. 146.

Examples of Free Exercise for the Hip Adductors

a. *stride lying or stride long sitting; Leg crossing.*

b. *sitting; Leg crossing.*

c. *Leg lift lying or reverse hanging; Leg parting and closing.*
d. *Leg lift lying or hanging; grasp and hold sandbag or ball between Feet or Knees.*

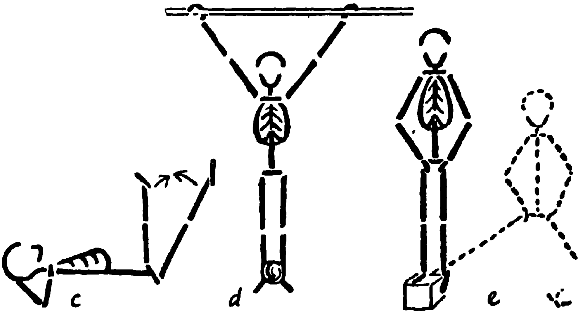


FIG. 117

e. *low wing Foot support sideways standing; push off with Foot on floor to take weight on supported Foot.*

Resisted Exercise for the Hip Adductors. Manual resistance at either the ankle or knees can be given to one or both legs (see Swedish Remedial Exercises, Nos. 11 and 12, pp. 196, 197). Resistance, by either

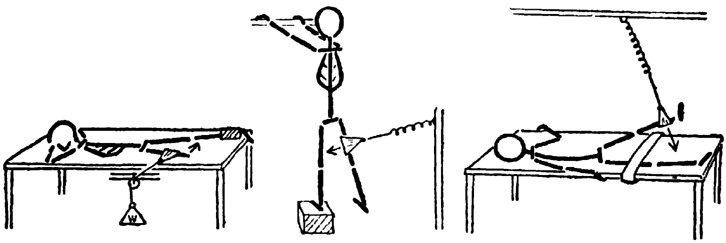


FIG. 118

springs or weights and pulleys, is conveniently applied in such positions as *lying, prone lying, side lying* or *reach grasp high half standing.*

Activities. Horse riding, breast-stroke swimming, rope climbing, roller skating and ski-ing work the muscles strongly.

THE MEDIAL ROTATORS OF THE HIP

Medial rotation of the hip is performed by the same muscles which abduct the femur, i.e. Tensor Fascia Lata, Gluteus Medius and

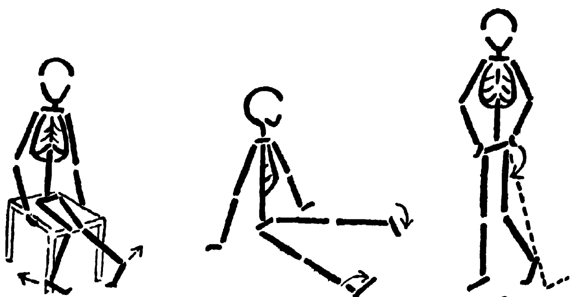
Minimus. Their action is relatively weak compared with that of the Lateral Rotators.

Assisted Exercise for the Medial Rotators of the Hip. Assistance is given manually with the knees and hips bent or straight, the grasps being the same as those used for the performance of the passive movement (Chapter 7, p. 85).

Examples of Free Exercise for the Medial Rotators of the Hip

The leg can be moved on the pelvis or the pelvis on the leg.

a. *sitting; swing or place the Feet apart, keeping the Knees together.*



a *b* *c*

FIG. 119

b. *stride lying or stride long sitting; Leg rolling inwards* (Fig. 119*b*).

c. *half standing; one Knee rolling inwards* (Fig. 119*c*).

d. *Knees bent prone lying; Feet pressing apart.*

e. *half standing; Pelvis and Trunk turning towards the standing Leg.*

Resisted Exercise for the Medial Rotators of the Hip. The muscles work against manual resistance during *Knee closing and outdrawing* (see Swedish Remedial Exercises, No. 11, p. 196), otherwise it is difficult to resist the movement without straining the knee. With traction on the extended leg in a few degrees of abduction, resistance can be offered on the inner border of the dorsiflexed foot.

Activities. Kicking, as in soccer, golf, and all movements which involve turning towards the stationary leg, use the muscles strongly.

THE LATERAL ROTATORS OF THE HIP

Lateral rotation is a powerful movement which is produced by many muscles (Obturators Internus and Externus, Quadratus Femoris, Gemelli Superior and Inferior, assisted by Piriformis, Gluteus Maximus, Sartorius and the Adductors).

Assisted Exercise for the Lateral Rotators of the Hip. Manual assistance is given in a manner similar to that used for the performance of the passive movement (Chapter 7, p. 196).

Examples of Free Exercise for the Lateral Rotators of the Hip

a. *cross sitting; press lateral side of Knee to ground.*
b. *stride lying or stride long sitting; Leg rolling outward.*
c. *half standing; Leg rotation to point Toe sideways.*
d. *Toe standing; Hip and Knee bending, parting Knees as far as possible.*
e. *stride prone lying; with Ankles dorsiflexed, press Heels inwards till medial border of Foot rests on floor.*

Resisted Exercise for the Lateral Rotators of the Hip. Manual resistance can be offered as these muscles work with the Abductors, during *Knee parting and Inpressing* (see Swedish Remedial Exercises, No. 9, p. 192), or it may be given on the outer border of the dorsiflexed foot and outer side of the knee, with the patient in *lying*, or *Back support long sitting.*

Activities. These muscles are used strongly during many movements in ballet dancing, Scots dancing and fencing.

THE MUSCLES OF THE PELVIC FLOOR

The Levatores Ani and Coccygei together form a pelvic diaphragm or muscular floor of the pelvis. The Levatores Ani constrict the lower end of the rectum (or 'back passage') and the vagina in the female, and support the pelvic viscera with the assistance of the Coccygei, which draw the coccyx forwards. The urethra (or 'front passage') is constricted by the Sphincter Urethrae.

Contraction of these muscles takes place in response to the pressure exerted on them by the downward thrust of the viscera, and the latter is increased by an increase in the intra-abdominal pressure. Their action also appears to be associated with that of the Hip Extensors and Adductors. Weakness or overstretching often leads to incontinence or prolapse which is most distressing to the patient.

Method of Teaching Contraction. Faradic stimulation may be necessary to teach the patient to appreciate the feeling of contraction, otherwise instruction to 'Draw up' the 'back passage' or 'front passage' is usually understood. This can be done as a localised movement or in conjunction with exercise for the Hip Extensors or Adductors.

Assistance is given to the muscles by positioning designed to reduce the effect of the downward thrust of the pelvic viscera, e.g. *crook lying with Pelvis lifted, lying,* or *prone lying.* Progression is made by using the inclined and finally the erect positions for exercises and maintenance of control.

Examples of Exercises in which the Muscles of the Pelvic Floor Work

a. *crook lying (with Pelvis lifted); brace Buttocks, press Knees together, and pull up between Legs.*
b. *Leg lift lying (Heels supported and Legs crossed); Hip raising and adduction with Pelvic Floor contraction.*

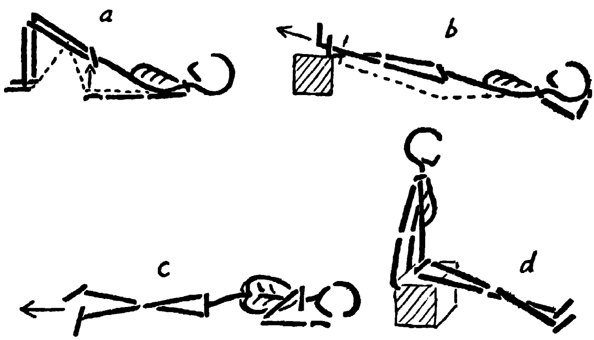


FIG. 120

c. *side lying (Legs bent); Leg stretching and adduction with Pelvic Floor contraction.*
d. *inclined long sitting (Ankles crossed); brace Buttocks, press Knees together and contract Pelvic Floor.*
e. *standing Legs crossed; Heel raising with Pelvic Floor contraction.*

Resisted Exercises for the Adductors of the Hip, particularly those which also use the Hip Extensors, are used, e.g. *crook lying; Knee closing (with Pelvis lifting) and outdrawing (with Pelvis lowering)* (see Swedish Remedial Exercises, No. 11, p. 196).

As control improves the contractions of the pelvic floor are maintained during general trunk and leg exercises and the patient is trained to brace the muscles before any activity which raises the intra-abdominal pressure, such as coughing, sneezing, laughing or lifting heavy weights.

THE MUSCLES OF THE TRUNK

The anterior and posterior muscles of the trunk, the Back and Abdominal Muscles, flex and extend the spine and combine to produce side flexion and rotation.

They may work to produce movement with their lower attachment on the pelvis fixed; with their upper attachment on the thorax fixed; or with both attachments free to move. When they work with both attachments fixed a static or postural contraction results, the balanced contraction of the muscles being responsible for the active posture of the trunk and the support of the abdominal viscera.

THE EXTENSORS OF THE SPINE

The Sacrospinalis Muscles are the principal extensors of the thoracic and lumbar spines. They can be assisted by Quadratus Lumborum in the lumbar region and by many of the deep muscles of the back; the latter, however, probably work mainly in a postural capacity. The muscles which extend the cervical region, and which frequently work with those of the other regions, will be considered elsewhere as Neck Extensors. Other muscles which work in conjunction with the Extensors of the Spine are the Retractors and Depressors of the Scapulae and the Extensors of the Hip.

Extension is free in the lumbar region of the spine and very limited in the thoracic region. The effective action of the muscles can be limited to one region only, they may work as a whole from a fixed point at their lower or upper attachment, or with both attachments free to move.

Assisted Exercise for the Extensors of the Spine. Gravity is neutralised in *side lying* and the action of the muscles may be assisted by hand. Owing to the weight of the part to be moved it is convenient to suspend the body from the waist downwards prior to movement. The physiotherapist places one knee in the patient's back to fix at the axis of movement and uses her hands to assist the action of the muscles.

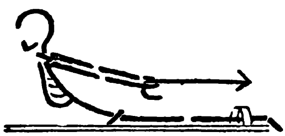


FIG. 121

As a progression, the support of a plinth with a polished surface may be used, or small movements of extension may be attempted against tension springs when the body is suspended in the supine position. In *prone lying* with the arms clasped behind the back and the feet fixed the patient's efforts can be assisted by horizontal traction on the arms.

Examples of Free Exercise for the Extensors of the Spine

a. *prone lying; Trunk raising.*

This exercise can be progressed and modified in numerous ways, for example:

(*i*) One or both legs can be lifted.

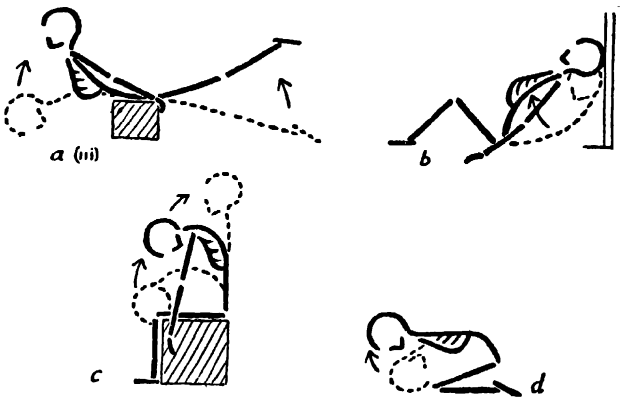


FIG. 122

(*ii*) The leverage of the trunk can be increased by elevating the arms to *bend, yard, Head rest* or *stretch positions.*

(*iii*) The hips may be supported on a form.

(*iv*) The raised position may be held while a ball is bowled or thrown to a partner (relax between each catch and throw).

(*v*) The ankles may be grasped when the knees are bent.

b. *crook lying, crook half lying, relaxed crook sitting, stretch crook sitting, or standing; Back arching* (Fig. 122.)

c. *relaxed stride sitting, or relaxed stride standing; Trunk raising vertebra by vertebra.*

d. *relaxed stoop kneel sitting; Trunk raising to the horizontal.*

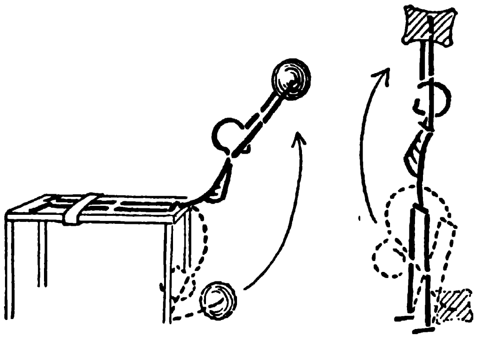
e. *prone kneeling or half yard grasp standing; one Arm and Leg lifting.*

f. *hanging; Leg lifting backward.*

Resisted Exercise for the Extensors of the Spine. Resistance can be given from *prone lying*, the physiotherapist placing one hand between the shoulder-blades and her other forearm fixing the thighs. Back Extension and Raising exercises are also suitable (see Swedish Remedial Exercises, Nos. 13, 14, pp. 197–9).

Weight resistance is simple and effective, for example:

(*i*) *relaxed Leg prone lying; Trunk raising to lift a medicine ball.*



(i) (ii)

FIG. 123

(*ii*) *relaxed stoop stride standing; Trunk raising to lift a sandbag above Head and lower it to the ground between the Feet.*

(*iii*) *prone lying with Feet fixed; Trunk raising (lifting sandbag placed between Shoulders) or Leg lifting (with sandbag between Feet).*

Spring or weight and pulley resistance is applied by means of a halter round the shoulders or by the patient holding the rope in the hands.

Activities. Rowing, tug-of-war, crawl-stroke swimming, arch and tunnel ball and all forms of lifting are some of the activities in which these muscles work.

THE FLEXORS OF THE SPINE

With the exception of the Transverus Abdominis, whose only function is to support and compress the abdominal viscera, all the Abdominal Muscles work to produce flexion of the spine. The Recti are the chief muscles responsible, but they are assisted by the Obliqui Internus and Externus. Gluteus Maximus produces flexion of the lumbar spine indirectly by tilting the pelvis backwards when it works with reversed origin and insertion.

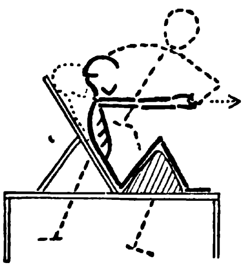


FIG. 124

Assisted Exercise for the Flexors of the Spine. Crook half lying is a suitable position for assisting concentric and eccentric work for these muscles. The patient lifts the head and draws the shoulders forward, help being given by horizontal traction on the arms and, if necessary, support behind the head. A wider range of movement is obtained by placing a small pillow behind the waist. In *side lying* the head and shoulders or the pelvis can be moved with the physiotherapist's assistance.

Examples of Free Exercise for the Flexors of the Spine

a. *crook lying, sitting, prone kneeling or standing; Pelvis tilting backward.*

b. *prone kneeling; Back humping and hollowing, slowly.*

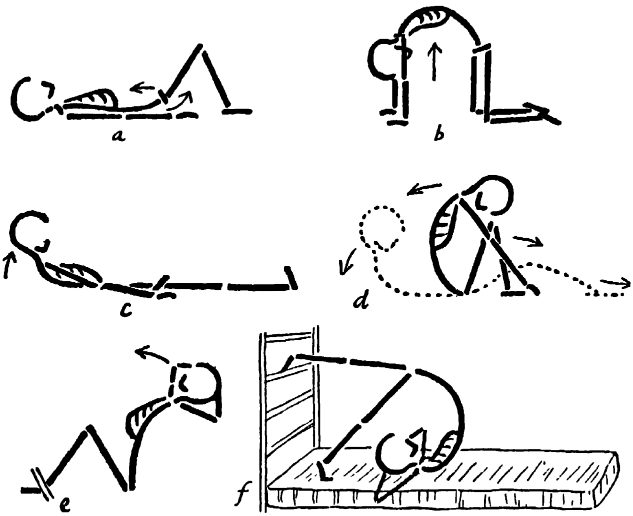


Fig. 125

c. *lying; Head and Shoulder raising to look at Feet.*

d. *relaxed crook sitting; change to lying (rounding Back) and raise.*

e. *Head rest crook sitting (Feet fixed); Back arching and raising.*

f. *lying; Hip and Leg lifting, to touch wall or floor behind Head (avoid accidental somersault).*

These muscles work strongly statically as fixators for the Hip Flexors and in many shoulder exercises, to prevent hollowing of the back, and when the head is lifted from *lying* they can be felt to tense. Compression of the abdominal viscera which involves relatively static work for the muscles is achieved by accenting the expiratory phase of breathing, when all the Abdominal Muscles (including Transversus) contract as the antagonistic muscle, the Diaphragm, is relaxed.

Resisted Exercise for the Flexors of the Spine. These muscles work strongly in association with the Hip Flexors, therefore resisted exercises for these muscles can be used to achieve concentric and eccentric work for the Flexors of the Spine. The movement must be continued to include tilting of the pelvis and flexion of the lumbar spine. (See Swedish Remedial Exercises, No. 2, *Knee updrawing and downpressing*, and No. 4, *Leg updrawing and downdrawing*, pp. 184, 187.) Resistance to rounding of the back from *lying* (*Feet fixed*) can be offered by a weight held on the chest or with the arms extended. Manual or mechanical means can be arranged from *high ride sitting* (see Swedish Remedial Exercises, No. 15, p. 200).

Gravity is usually a sufficiently strong resistance when the muscles are worked in their outer range, but a weight held on the chest or in

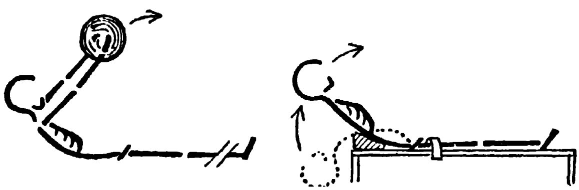


FIG. 126

extended arms increases the load in *lying; change to long sitting* and in *lying* (*Head and Shoulders unsupported*)*; Back arching slowly and raising.*

Activities. Examples of these are long jumping, hurdling, somersaults, squat vaults, and climbing.

THE SIDE FLEXORS

The Back and Abdominal Muscles of one side work together to produce side flexion. The chief muscles concerned are the Sacrospinalis, Quadratus Lumborum, Rectus Abdominis and the Internal and External Obliques. When the arms are fixed and the pelvis is free to move, Latissimus Dorsi, working with reversed origin and insertion, can produce the movement by lifting the pelvis upwards and forwards. Strengthening and hypertrophy of the latter are of major importance in the rehabilitation of those who have sustained injury to the spinal cord.

Assisted Exercise for the Side Flexors. Prone lying with the trunk suspended over the end of the plinth is suitable for movement of the upper part of the body in the neutral position (see p. 92, Fig. 70c). For movement of the lower part of the body *heave grasp lying* with the pelvis and legs suspended is often used, particularly when work is required for Latissimus Dorsi. A plinth with a polished surface may be substituted for suspension or the body may be floated in a re-education pool. Manual assistance and control of the movement is given in every case.

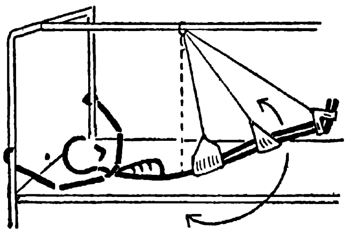


FIG. 127

Note. In Fig. 127 above the axis of movement is over the moving joint and the plane of pelvic movement is horizontal. If the axis is moved towards the feet, a pendular swing results, increasing the difficulty at the limit of side flexion provided movement is at a speed slower than that of the natural swing of the pendulum. During a pendular swing some rotation of the pelvis accompanies the movement of side flexion.

Examples of Free Exercise for the Side Flexors. This movement is free in the lumbar region and limited in the thoracic region. Sometimes it is necessary to limit the action of the muscles to one region only, as for instance in unilateral exercise for partially mobile scoliosis. To promote the thoracic movement, exercises involving the arms or those with the lumbar region fixed in flexion are preferable. For lumbar movement, exercises for the legs are most effective and movement of the whole spine is freest in weightless exercises in extension.

1. Mainly for the Thoracic Region
   - a. *inclined prone kneeling; low Dog crawl* (see Fig. 82 p. 110).
   - b. *bend stoop stride sitting; one Arm stretching upwards with one Arm stretching downwards (to limit of movement).*
   - c. *under bend stoop stride sitting; Trunk side bending, localising movement with fists.*

2. Mainly for the Lumbar Region
   - d. *reach grasp standing; one Leg shortening.*
   - e. *hanging; Leg lifting sideways.*
   - f. *standing; one Leg lifting sideways or swinging sideways with hopping.*

3. For the Whole Spine
   - g. *yard Foot support sideways standing; Trunk side bending, with opposite Arm swinging overhead.*

h. *Forehead support prone lying; Trunk raising followed by Trunk side bending.*

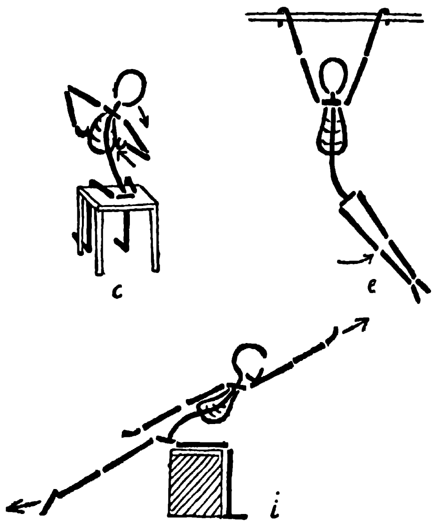


FIG. 128

4. Bending to Opposite Side in the Two Regions

i. *bend fallout sitting; one Arm stretching upwards and other Arm downwards with lateral rotation of the latter.*

The lumbar region is bent to the side of the sitting leg and the thoracic to the side of the arm which is upward.

Resisted Exercise for the Side Flexors. The muscles work against manual resistance during *reach grasp high half standing; single Leg parting and impressing* and *bend half lying; single Arm stretching and downpressing* (see Swedish Remedial Exercises, pp. 194 and 205).

In the upright position a weight held or lifted in one hand is a simple method of resistance, a vertical throw of a medicine ball above the head provides strong work for the muscles.

Activities. Most movements of lifting and reaching up with one arm work these muscles. Overarm bowling, window cleaning and climbing a rope are examples. In walking, running, and creeping, movement of the pelvis involves side flexion, although the range of movement is small.

THE TRUNK ROTATORS

The Back and Abdominal Muscles combine to produce rotation, which takes place mainly in the lower thoracic region. The fibres of the muscles concerned lie obliquely, i.e. the trunk rotators to the right lie in the direction of an oblique line running downwards and to the right anteriorly (right Internal Oblique, left External Oblique) and downwards and to the left posteriorly (left Rotatores, right Multifidus).

Assisted Exercise for the Trunk Rotators. Rotation is assisted manually in the *sitting* position by horizontal pressure on the front of one shoulder and on the back of the other. From *lying*, the patient can be helped to rotate and roll over on to one side, or into the *prone* position. To do this the physiotherapist stands on the side of the bed towards which the patient turns and the upper arm and leg are folded across the body and the pelvis is rolled on to one side with the help of one of the physiotherapist's hands on the sacrum, then her other hand brings the shoulders into line, with pressure on the scapula.

Examples of Free Exercises for the Trunk Rotators

a. *yard crook lying; Pelvis and Leg rolling from side to side.* The leverage is increased by stretching one or both Knees and lifting the Legs.
b. *ride sitting; Trunk rotation to alternate sides with loose Arm swinging.*

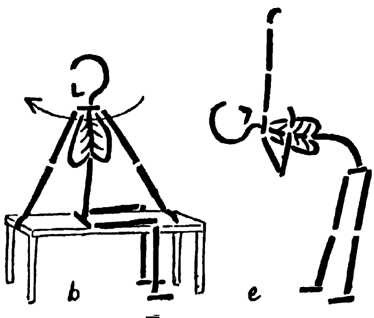


FIG. 129

c. *prone kneeling; Trunk rotation with one Arm reaching upwards to receive a beanbag and then pass it back to partner under the Trunk.*
d. *ring grasp cross or ride sitting (with partner); Trunk rotation while one Arm bends as the other stretches.*
e. *stoop stride standing or yard Legs crossed standing; Trunk rotation with loose Arm swinging.*
f. *cross or ride sitting; Trunk rotation to pass ball to physiotherapist, who stands behind.*

Resisted Exercise for the Trunk Rotators. Trunk rotation in *wing close sitting* with manual resistance is described elsewhere. See Swedish Remedial Exercises, No. 16, p. 201. Weights held in the

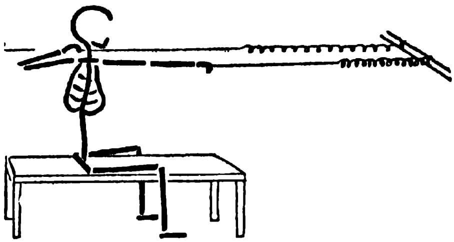


FIG. 130

hand can be added in *pronc kneeling; Trunk rotation* (as in Free Exercise 'c'). Spring or weights and pulleys are arranged horizontally with the patient in *reach grasp ride sitting.*

As breathing is impeded in the turn position, frequent rests may be necessary, or the exercises can be performed with breathing (expiration with turning and inspiration in the neutral position).

Activities. Examples of these are sawing, running, archery, tennis, golf, overarm throwing, punching.

THE PELVIS ROTATORS

The pelvis can be rotated while the legs and shoulders remain stationary.

When the whole body is in alignment the Pelvis Rotators to the

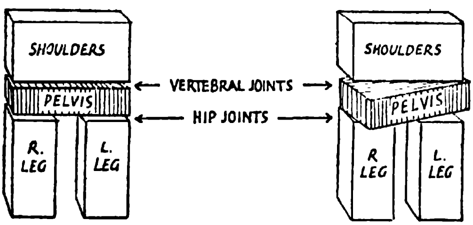


FIG. 131

left are the right Trunk Rotators, the Medial Rotators of the left Leg, and the Lateral Rotators of the right Leg, all working with reversed origin and insertion.

THE ELEVATORS OF THE SHOULDER GIRDLE

Elevation of the shoulder girdle frequently accompanies elevation of the arm but it may occur independently, as in shoulder shrugging. The muscles responsible for the movement, Trapezius (upper fibres) and Levator Scapulae, also steady the scapula during movements of the shoulder, maintain the postural level of the shoulders and (working with reversed origin and insertion) draw the head backwards. If the muscles work on one side only the head is bent to that side.

Assisted Exercise for the Shoulder Elevators. The work of these muscles is reduced in shoulder shrugging when the body is in the horizontal position as gravity is neutralised, e.g. in *crook lying* and *prone kneeling*. Manual assistance to the movement or to the maintenance of a higher postural level may be given by pressure under the elbows when the arms are folded. Assistance to head movements is described on p. 179.

Examples of Free Exercises for the Shoulder Elevators

a. *crook lying, prone kneeling or sitting; Shoulder shrugging.*
b. *crook lying or prone kneeling; Head side bending* (with or without Shoulder shrugging).
c. *stride standing or sitting: any Arm movement above the horizontal* (including ball throwing).

In training a new postural level of the shoulder girdle it is essential for the patient to appreciate the 'feeling' of the new level. The use of a mirror may be helpful at first but this has the disadvantage of encouraging the patient to use the sense of sight as a substitute for kinaesthetic sense and therefore should be discontinued as soon as the patient can 'feel' the new position.

Resisted Exercise for the Shoulder Elevators. The physiotherapist's hands or sandbags resting on the patient's shoulders, or weights held in his hands, resist the shrugging action of the muscles. Spring or weight and pulley circuits can also be used. Resistance to elevation of the arms is given by lifting a medicine ball above th head or in *heave grasp half lying; Arm stretching upward and downpressing* (see Swedish Remedial Exercises, No. 19, p. 204).

The muscles antagonistic to the Elevators are the Serratus Anterior (lower fibres) and Pectoralis Minor, which work as Depressors when the movement is not performed by gravity. Latissimus Dorsi, however, is mainly responsible for downward pressure of the arms and shoulder girdle when resistance to the movement is given on the arms.

THE PROTRACTORS OF THE SCAPULAE

(Muscles which move the Scapulae forwards round the Chest wall)

Serratus Anterior and Pectoralis Minor move the scapulae forwards round the chest wall so that the glenoid cavity looks approximately forwards. Flexion of the gleno-humeral joint is usually associated with the movement, as in forward pushing or punching. The vertebral border of the scapula is held in apposition to the chest wall by Serratus Anterior with the assistance of Latissimus Dorsi.

Examples of Free Exercise for the Protractors of the Scapulae

a. *Back support sitting; Shoulder drawing forward to round the upper Back and to place each Hand behind the opposite Shoulder* (avoid stooping).
b. *half lying or lying; punching movement with Arms.*
c. *reach support standing (Hands on wall); Trunk falling forwards from Ankles and push off with Hands to regain balance.*
d. *prone falling; Arm bending and stretching ('press ups').*

Resisted Exercise for the Protractors of the Scapulae. Forward movement of the shoulders can be resisted by manual pressure on the front of the shoulder joints in any position in which the back is supported. Resistance to forward pushing with the arms is given in *crook lying* by lifting a weight vertically upwards from the chest, or by springs or weights and pulleys in *Back lean standing.* Excessive trunk rotation should be avoided when one arm only is used.

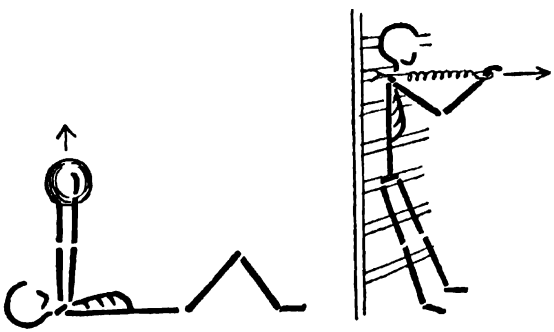


FIG. 132

Activities. Punch-ball, boxing, digging, sawing, bowls, and forward throwing of a ball all work these muscles strongly.

THE RETRACTORS OF THE SCAPULAE

These muscles (Rhomboid Major and Minor, Trapezius, middle fibres) approximate the vertebral borders of the scapulae, bracing back the shoulders and steadying the scapulae during movements of the arms. They frequently work with the Extensors and Lateral Rotators of the Shoulders and the Extensors of the Spine but they can be activated independently.

Assisted Exercise for the Retractors of the Scapulae. The arm is used to lever the scapula round the chest wall when assisting the action of these muscles.

The physiotherapist uses one hand to palpate the scapula and to press it against the chest wall while her other hand grasps the patient's upper arm which is flexed and abducted into the plane of the scapula. *Prone lying* at the side of the plinth is the starting position of choice, as the trunk is fixed without pressure on the scapula.

Examples of Free Exercise for the Retractors of the Scapula

a. *sitting; Arm rotation laterally with deep breathing and Scapula retraction.*
b. *relaxed crook sitting; Back arching.*
c. *across bend sitting; Elbow pulling backwards.*

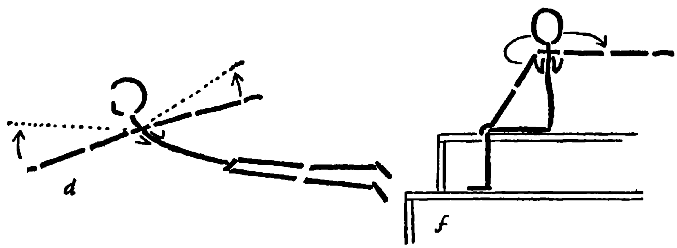


FIG. 133

d. *yard prone lying; Head and Shoulder and Arm raising.*
e. *fall hanging; Arm bending.*
f. *high ride sitting; Trunk turning with one Arm pressing backward.*

Resisted Exercise for the Retractors of the Scapulae. The action of the muscles can be localised fairly well when they work against manual or mechanical traction given on the arm in the plane of the scapula. *Yard palms forward stride sitting; Arm forward drawing and parting* (See Swedish Remedial Exercises, No. 17, p. 202) works the Retractors with the Shoulder Extensors and any form of resistance offered to pulling

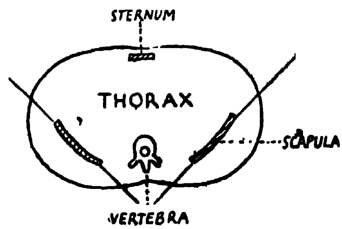


FIG. 134. Horizontal Section of Thorax to show Plane of the Scapula

movements or lifting from stooping, with or without trunk rotation, can be employed.

Activities. This group of muscles is used in breast-stroke swimming, rowing, tug-of-war. The use of a rake or saw (backward movement) is an example of how the Retractors help to steady the scapula and maintain the poise of the shoulders during a wide variety of skilled occupational movements in which the arms are used.

ROTATION OF THE SCAPULA

Lateral or forward rotation of the scapula (so that the glenoid cavity looks upwards) is accompanied by scapula protraction and is inseparable from movement at the gleno-humeral joint during elevation of the arm. The chief muscles concerned are Serratus Anterior and Trapezius (upper and lower fibres).

Medial or backward rotation, which is the reverse movement, is produced by the Levator Scapulae and the Rhomboids, assisted in their outer range by Pectoralis Minor.

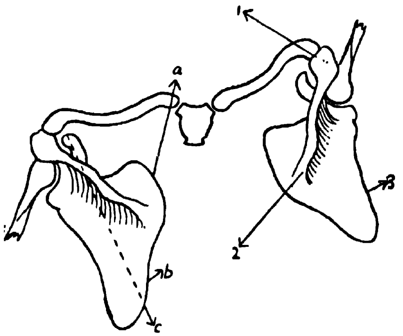


FIG. 135. Rotation of the Scapula

Medial Rotators	Lateral Rotators
a. Levator Scapulae	1. Trapezius (upper fibres)
b. Rhomboids	2. Trapezius (lower fibres)
c. Pectoralis Minor	3. Serratus Anterior

Paralysis of Serratus Anterior is not uncommon and re-education as power returns requires consideration, because of the variety of functions the muscle performs.

The actions of the muscle are—(1) Protraction of the scapula with Pectoralis Minor, usually during pushing or thrusting movements of the arm; (2) Lateral Rotation of the scapula with Trapezius, in association with gleno-humeral movement to elevate the arm; (3) Stabilisation of the scapula, to fix the origin of Deltoid, to keep the scapula against the chest wall and to prevent medial rotation when weights are carried in front of the body; (4) Elevation of the ribs in inspiration when the arms are fixed; in this case it works with reversed origin and insertion.

The muscle may work as a fixator (3) at an early stage of recovery, but this is difficult to assess, therefore re-education of Protraction and Lateral Rotation are attempted.

EARLY RE-EDUCATION OF SERRATUS ANTERIOR

Protraction

Eccentric work for the muscle in middle range is provided by drawing the arm partially forwards and outwards at right angles to the body with one hand, while pressing the scapula to the chest wall with the other. Then the patient is asked to hold the position while the scapula is levered backwards round the chest wall by pressing the head

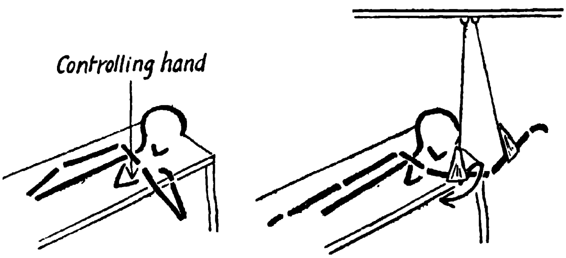


FIG. 136

of the humerus against the glenoid cavity. The physiotherapist can feel the movement throughout w'ʻh the hand which presses the scapula to the chest wall. *Prone lying*, with the arm over the side of the plinth, or *stoop sitting*, with the trunk supported by the patient's free arm, is a suitable starting position. The reverse movement works the muscle concentrically.

Lateral Rotation

Prone lying, with the arm supported by hand or in suspension, is satisfactory as a starting position. The arm is partially elevated and the patient attempts to maintain the position as it is drawn towards the body. The physiotherapist can both see and palpate the movement of the scapula, or can assist it with her fingers.

Further re-education continues according to general principles.

THE SHOULDER FLEXORS

Pectoralis Major (clavicular portion) and Deltoid (anterior fibres) are the chief muscles concerned in flexing the gleno-humeral joint. Their action is reinforced by assistance from the sternocostal portion of

Pectoralis Major and by Biceps when the arm is drawn into line with the body from the fully extended position. The Shoulder Flexors work with the Scapula Protractors and the Elbow Extensors to produce the group movement of joints which results in a forward thrust of the arm.

Assisted Exercise for the Shoulder Flexors. The muscles can be worked with the arm in abduction or adduction. Assistance is given manually, with the same grasps which are used for the passive movements, the shoulder girdle being fixed to localise the movement.

Side lying with the arm adducted and supported horizontally in axial suspension eliminates gravity, and the movement can be free or assisted by the physiotherapist. Flexion of the elbow with extension of the shoulder and vice versa follows the natural pattern of movement and prevents an aimless swing of the arm. A measure of resistance (less than that of gravity acting on the arm in the erect position) is introduced by using pendular suspension, the overhead attachment of the suspending ropes being moved backwards behind the axis of the shoulder joint. Auto-assistance with a rope and pulley may be arranged in *sitting* or *half lying* with the pulley overhead.

Examples of Free Exercise for the Shoulder Flexors. Exercises already suggested for the Protractors of the Scapula are suitable for these muscles also. In addition the following are useful:—

a. *half bend side lying; one Shoulder flexion.*

b. *crook lying; alternate Arm lifting upwards and downwards.*

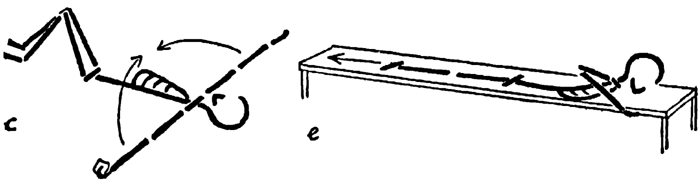


FIG. 137

c. *yard crook lying; Arm lifting to the vertical (to pass beanbag from one Hand to the other).*

d. *bend sitting; Arm stretching forwards.*

e. *bend grasp prone lying (on form); Arm stretching to push body backwards along the form ('Reverse Seals').*

Resisted Exercise for the Shoulder Flexors. Lifting of weights held in the hands in a forward direction is a simple method of resistance; flexion of the elbow accompanying the movement which reduces the leverage in the initial stages can be included or not as required. *Crook lying* with the moving arm free over the side of the plinth, *walk standing* or *sitting* on a chair, are suitable starting positions. Spring or weight and pulleys can be used to resist the forward thrust of the arm.

Activities. These are very numerous and include many household chores, such as scrubbing, polishing, washing, ironing, and hanging

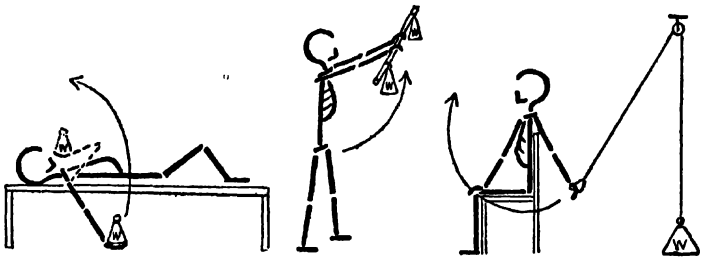


FIG. 138

out clothes, and using a hand sewing-machine; garden jobs, such as digging, hoeing, and hedge clipping; recreations, such as weight lifting, throwing a ball over- or underarm or serving at tennis; work involving planing, sawing, stoking or painting.

THE SHOULDER EXTENSORS

The muscles which extend the shoulder are Deltoid (posterior fibres), Teres Major, Latissimus Dorsi and Pectoralis Major (sterno-costal portion). The first two muscles are primarily responsible for the inner range, when the arm is drawn backwards from the plane of the trunk. Latissimus Dorsi and Pectoralis Major, on the other hand, are powerful extensors from the fully flexed position until the arm is drawn into line with the trunk, as in chopping movements or in pulling the body upwards on the arms from hanging. With the exception of Pectoralis Major, the muscles also work strongly to achieve the final elevation of the arm.

Assisted Exercise for the Shoulder Extensors. Side lying with the arm suspended in slings or supported on a re-education board eliminates gravity for early re-education. Flexion of the elbow as the muscles approach the inner range of contraction shortens the leverage in the weakest part of the range and follows the natural pattern of movement. Extension in abduction can be used to work Deltoid and Teres Major, the patient *sitting* with the arm supported horizontally. In this position the pull of Pectoralis Major is antagonistic to the movement, and Latissimus Dorsi works at a distinct disadvantage owing to the obliquity of its pull.

Examples of Free Exercise for the Shoulder Extensors

a. *prone lying; Head and Shoulder raising with Arm lifting backwards.*
b. *stoop stride standing; alternate Arm swinging forward and backward.*
c. *yard or stretch prone lying; Arm lifting.*

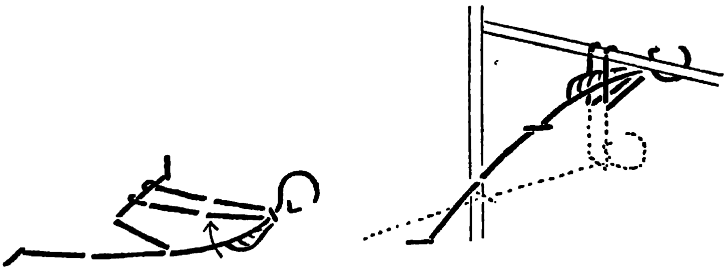


FIG. 139

d. *stretch prone lying (forms); Arm bending to draw body along ('Seals').*
e. *under grasp fall hanging (bar or rings); Arm bending, to raise Chest to bar.*
f. *climbing wall-bars or ladder using the Arms, or rope climbing.*

Resisted Exercise for the Shoulder Extensors. The physiotherapist resists extension with one hand placed behind this elbow as the patient draws the arm downwards and backwards. The shoulder girdle can be fixed or not as required, by the other hand. From *half reach prone lying*, with a weight held in the hand, a wide range of extension is

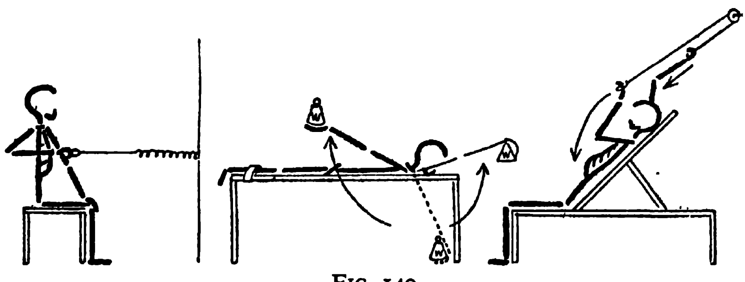


FIG. 140

resisted by gravity and the weight, as the arm is lifted. In this position overhead extension to elevate the arm is strongly resisted also.

Weights and pulleys, springs and self-resistance can be arranged so that the pull is in line with the trunk for resistance of the downward movement and at right angles to the trunk for the backward movement.

Activities. The muscles work during any form of climbing in which the arms play a part, in chopping and pulling movements and in crawl-stroke swimming.

THE SHOULDER ABDUCTORS

Abduction is initiated by Supraspinatus and continued by Deltoid. Provided the shoulder girdle is free to move, lateral rotation of the scapula invariably accompanies movement at the gleno-humeral joint. To localise the work of the Shoulder Abductors, the shoulder girdle must be fixed, and in these circumstances abduction is possible to about 80°. Some lateral rotation of the humerus is essential to permit abduction, and the ability to perform this movement must be tested.

Deltoid is often paralysed by injury to the Circumflex nerve, and lesions of the Supraspinatus tendon may prevent or interfere with the initiation of the movement and the subsequent action of this muscle, which is to steady the head of the humerus and prevent it from gliding upwards in the glenoid cavity as the result of the upward pull of Deltoid on the bone.

Assisted Exercise for the Shoulder Abductors. A method of assisting the action of the Abductors has already been described on p. 150.

Examples of Free Exercise for the Shoulder Abductors. It is essential to teach the patient to abduct the arm by lifting the elbow outwards while the point of the shoulder remains depressed, otherwise the normal pattern of the movement becomes distorted by excessive scapula movement in the initial stages.

a. *bend crook lying; Shoulder abduction.*
b. *side lying; one Arm lifting and slowly lowering.*
c. *side towards walk standing; creep one Arm up the wall.*
d. *bend sitting; Arm stretching sideways and upwards.*
e. *sitting; Arm lifting sideways and upwards to throw or pass ball from Hand to Hand.*
f. *yard stride standing; Arm swinging across body and sideways, upward.*

The muscles work strongly, and mainly statically, in any exercise in which the arm is held abducted, e.g.—*across bend sitting; alternate Arm flinging with Trunk rotation,* or *yard standing; Arm circling in small range to spin a hoop round the Wrist or one Finger.*

Resisted Exercise for the Shoulder Abductors. Manual resistance can be localised by fixing the shoulder girdle to prevent scapula movement. The fixing hand is placed so that pressure is directed downwards in line with the trunk, the fingers lying over the clavicle and the thumb on the spine of the scapula.

Swedish Remedial Exercises, Nos. 19 and 18, *Arm upward stretching and downpressing* and *Arm lifting and downpressing*, work the Shoulder Abductors with the Lateral Rotators of the Scapula. Weights held

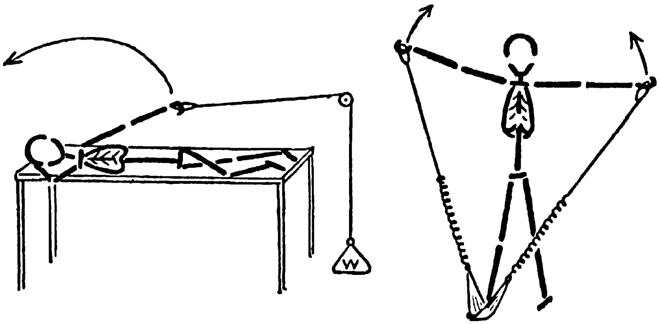


FIG. 141

in the hands are lifted sideways upwards and slowly lowered; this should be done bilaterally to avoid transference of the movement to the spine (side flexion). Weight and pulley, and spring resistance can be applied to either the upper arm or through the hands.

Activities. These muscles work during overarm bowling in cricket, skipping with a rope, 'Butterfly' breast-stroke swimming, and lifting and carrying a bucket in one hand.

THE SHOULDER ADDUCTORS

In the erect position the movement of adduction is usually performed by gravity or controlled by the Shoulder Abductors. As the Shoulder Adductors (Pectoralis Major, Latissimus Dorsi, Teres Major and Coraco-brachialis) all work in some other capacity to produce movement in the shoulder joint, strengthening of this movement, as such, is rarely required. However, the muscles must be activated in their capacity as Adductors to maintain the pattern of movement in cases of general weakness and instability of the shoulder joint.

THE LATERAL ROTATORS OF THE SHOULDER JOINT

Infraspinatus, Teres Minor, and Deltoid (posterior fibres) work to rotate the gleno-humeral joint laterally. The movement is of considerable importance as it is essential for elevation of the arm through abduction (in the coronal plane).

Assisted Exercise for the Lateral Rotators of the Shoulder Joint. Assistance to the action of the muscles is given with the patient's elbow bent to a right angle and the arm either adducted or abducted, the range of movement being greater in the former position. With one hand the physiotherapist grasps just above the elbow giving traction on the humerus, and this hand acts as a pivot for the movement of the patient's forearm as this is grasped and carried outwards from across the body when the humerus is in the adducted position. Alternatively, support of the arm in slings may be used. See Fig. 75, p. 100.

Examples of Free Exercise for the Lateral Rotators of the Shoulder Joint

a. *sitting (Elbows bent and tucked in); wide clapping movements in the horizontal plane, with emphasis on Hand parting.*
b. *crook lying or sitting; clasp Hands behind Head.*
c. *stride standing (grasp stick in both Hands); Arm lifting and Elbow bending, to put stick behind Shoulders.*

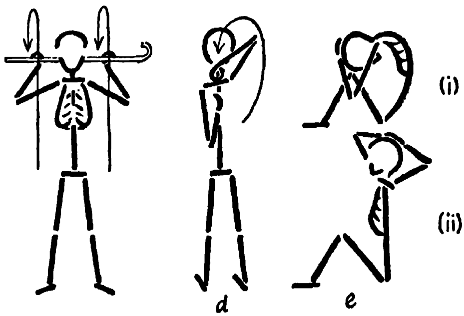


Fig. 142

d. *standing; pass beanbag over Shoulder with one Hand (Lateral rotation) to other Hand behind Waist (Medial Rotation).*
e. *Head rest relaxed crook sitting; Head and Trunk raising with Arm parting, 'cover the Face, then show the Face'.*
f. *sitting; Arm rotation (medial and lateral alternately) during Arm lifting sideways upwards and lowering.*

Resisted Exercise for the Lateral Rotators of the Shoulder Joint. Manual resistance is given in a manner similar to that used for assistance. In *side lying*, with the arm adducted and stabilised by the physiotherapist or by the patient's other hand, a weight is lifted in the hand from the plinth until the forearm is vertical.

Resistance with the arm abducted and the elbow bent is given on the hand or wrist by any suitable means. Support of the upper arm is essential but it is difficult to make this stable without interfering with the movement.

THE MEDIAL ROTATORS OF THE SHOULDER JOINT

Pectoralis Major, Latissimus Dorsi, and Deltoid (anterior fibres) rotate the humerus medially and are assisted by Subscapularis in the adducted position. Inner range work for the muscles is required to put the hand behind the back, but, although the pattern of movement must be maintained by attempting to perform it, the muscle power is trained more successfully by working the muscles concerned in their other capacities.

THE ELBOW FLEXORS

Brachialis, Biceps and Brachioradialis are the prime movers in elbow flexion. The action of Brachialis is unaffected by the position of pronation or supination of the forearm, as its attachment on the ulna remains steady during movement at the radio-ulnar joints. Brachioradialis is most effective as a flexor in the mid-prone position, when it has a straight pull. Biceps works to the best advantage when the shoulder joint is extended, as it passes over the anterior aspect of this joint. Pronator Teres is enlisted to give assistance when strong resistance is offered.

Assisted Exercise for the Elbow Flexors. The physiotherapist can give assistance to the muscles with the patient's arm in adduction or abduction. To localise the movement, she fixes the upper arm with one hand and helps to flex the forearm with the other, directing the patient's hand towards his mouth. On returning to the extended position allowance must be made for the carrying angle (Fig. 144).

Gravity is eliminated by supporting or suspending the arm in the horizontal position, with the patient in *side lying* or *sitting*. To obtain the maximum efficiency of Biceps, movement of the elbow should be preceded or accompanied by extension of the shoulder, as in the natural withdrawal movement of the arm.

Examples of Free Exercise for the Elbow Flexors

a. *sitting; Arm bending and stretching* (*accent on bending*).

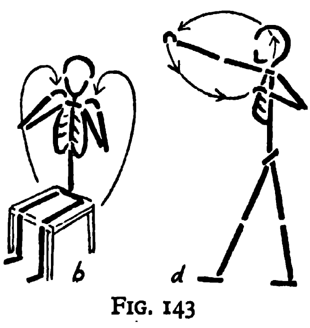


FIG. 143

b. *sitting; Arm swinging sideways and upwards with bending, to tap Shoulders.*
c. *standing; catch a light ball in the Hands.*
d. *half reach walk standing; Elbow bending and stretching with Shoulder extension and flexion (as if to draw a circle).*
e. *hanging or fall hanging; Arm bending.*

Resisted Exercise for the Elbow Flexors. In treating weakness resulting from traumatic injury only free weightless exercises are used until all danger of myositis ossificans has passed, or resistance exercises are ordered by the doctor in charge of the case.

For manual resistance the patient is in *lying*, or *half lying*, with the

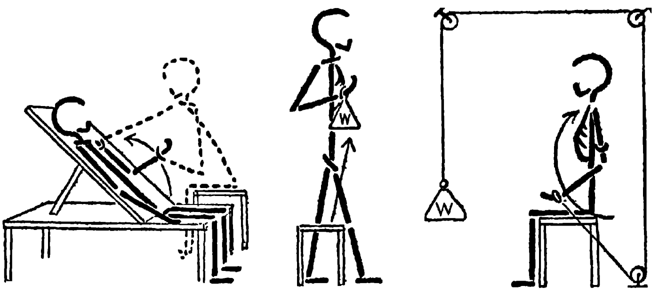


FIG. 144

upper arm supported on the plinth and fixed by one of the physiotherapist's hands, the movement being resisted by her other hand placed on the anterior aspect of the patient's forearm.

Lifting a weight held in the hand provides a simple and measurable form of resistance, and weights and pulleys or springs can also be employed in the final stages.

Activities. These muscles work strongly in all lifting movements.

THE ELBOW EXTENSORS

Triceps, assisted by Anconeus, extends the elbow. In giving assistance or resistance to these muscles allowance must be made for the carrying angle.

Assisted Exercises for the Elbow Extensors. These are arranged in a manner similar to that already described for the Elbow Flexors, but in this case, when movement is not localised to the elbow joint, it is combined with shoulder flexion, as it then most nearly approaches the natural thrusting movement.

Examples of Free Exercise for the Elbow Extensors. Pushing, thrusting and flinging movements, during which the upper arm is held horizontally or vertically, bring the muscles into action.

a. *across bend sitting; Arm flinging.*
b. *bend crook lying; Arm stretching vertically upwards.*
c. *prone lying or sitting with Arm supported on a table; Arm reaching forwards to touch or retrieve some object.*
d. *walk standing; punching movement freely or against punch-ball.*
e. *prone falling; Arm bending and stretching.*

Resisted Exercise for the Elbow Extensors. Manual resistance may be given when movement is localised to the elbow joint or when elbow extension is performed in conjunction with shoulder flexion. The

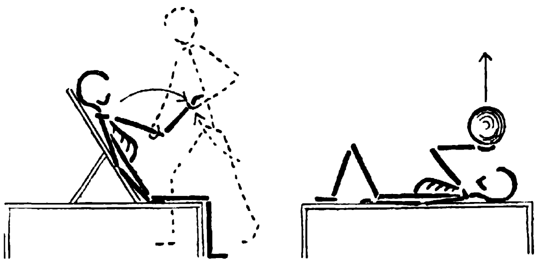


FIG. 145

angle at which resistance is given must be carefully adjusted to the carrying angle to avoid strain upon the joint.

Weights lifted vertically in the hands when the body is in *crook lying*, or *standing*, provide work for the muscles. Weights and pulleys or springs can be arranged to give resistance to elbow extension in a manner similar to that shown in Fig. 41, p. 51.

Activities. Overarm throwing, punching, sawing, scrubbing and polishing movements all involve the use of these muscles.

THE SUPINATORS

Supinator is the chief muscle involved in supinating the forearm. When the elbow is flexed it is powerfully assisted by Biceps Brachii, and Brachioradialis also helps in the outer range of the movement.

Assisted Exercise for the Supinators. Manual assistance is the most usual method. With the patient's elbow flexed to a right angle to eliminate the possibility of shoulder movement, the physiotherapist fixes the lower end of the humerus with one hand and with her other hand she either grasps round the patient's wrist or takes a handshake grasp with her first and second fingers extended across its anterior aspect to stabilise it. Slight traction is given in the long axis of the forearm and the patient is instructed to turn his palm upwards as the physiotherapist gives assistance.

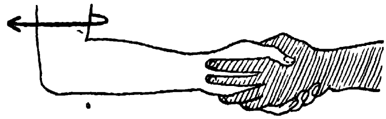


FIG. 146. Modified Handshake Grasp for assisting or resisting Supination

Self-assistance is sometimes useful, the patient clasping his fingers in front of him with the palms downwards and elbows bent, then rotating both forearms until the palms face upwards.

Examples of Free Exercise for the Supinators

a. *sitting, Forearm supported; pick up matches and rotate Forearm on little Finger to hand them to physiotherapist.*

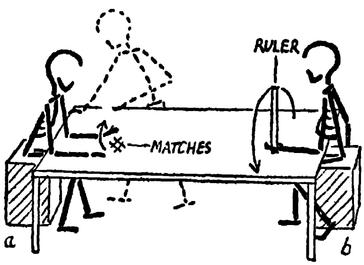


FIG. 147

b. *sitting, Forearm supported; tap ruler held in Hand from side to side on the table.*
c. *standing, upper Arm held to Side; screwing movement as to turn door-handle or use screwdriver.*
d. *sitting; pick up ball from table and throw it upwards.*

Resisted Exercise for the Supinators. Resistance can be given by the physiotherapist who uses the same grasp as for assistance. Additional leverage can be gained if she grasps the ends of a stick and resists the efforts of the patient to rotate. See Fig. 79, left, p. 104, for diagram of free movement

A Wrist Pronator and Supinator Machine may be used if available. This consists of a handle which rotates on a horizontal axis, the resistance offered being adjustable by means of a screw. With the elbow flexed and the forearm in line with the axis of rotation, the patient grasps the handle of the machine and supinates to rotate it.

Activities. These muscles work when a spoon is used to carry food to the mouth and to bring the palm of the hand in contact with the face. All activities which involve screwing movements can be practised; sewing and plaiting 'under' are useful movements especially for women.

THE PRONATORS

Pronator Teres and Pronator Quadratus are the muscles mainly responsible for pronation. They are assisted by Palmaris Longus and Flexor Carpi Radialis and by Brachioradialis in the outer range of movement.

Work for this group is provided by methods similar to those used to work the Supinators, but the movement takes place in the reverse direction as, for example, in unscrewing.

THE MUSCLES OF THE HAND

The Wrist Extensors

The wrist is extended by Extensor Carpi Radialis Longus, Extensor Carpi Radialis Brevis and Extensor Carpi Ulnaris assisted by the long Extensors of the fingers. The muscles work strongly as synergists during the action of gripping when the wrist is extended to increase the leverage of the long Flexors of the Fingers.

Assisted Exercise for the Wrist Extensors. For manual assistance the physiotherapist fixes the patient's forearm with one hand and grasps round the metacarpal bones with her other hand, so that her fingers lie in the palm and her thumb across the back of the patient's hand. The patient is instructed to allow the fingers to bend during the movement of wrist extension to relax the tension of the long Flexors and to follow the natural pattern of the gripping movement. The effect of gravity is counterbalanced when the forearm and ulnar border of the hand rest on a horizontal surface such as a polished table top or a spring may be incorporated in a 'lively' splint.

Examples of Free Exercise for the Wrist Extensors. The natural movement of gripping forms the basis of all free exercises in which these muscles work, and the sensory stimuli received from the hand when an object is grasped are of great importance. When the muscles are weak it is an advantage to perform the movement with both hands simultaneously and, if possible, with the forearms and hands submerged in warm water.

a. *sitting (Forearm and ulnar border of Hand supported); Wrist extension as the Hand grasps a rubber or wool ball.*
b. *sitting (anterior aspect of Forearm supported, Hand relaxed over*

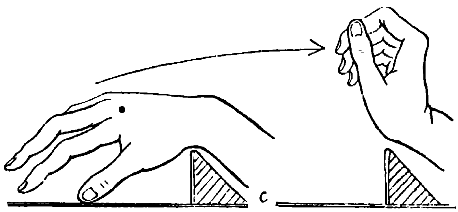


FIG. 148

edge of table); Wrist extension to make a fist and grasp some light object.
c. *sitting (Forearm and Finger-tips supported on table); Wrist extension to make staccato tapping movements of Fingers on table.*
d. *sitting; grasp and squeeze a tennis ball.*

Resisted Exercise for the Wrist Extensors. Manual resistance can be offered with the same grasp as for assistance. Other forms of resistance are applied with the patient grasping a stirrup handle and

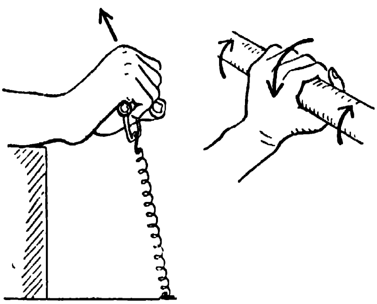


FIG. 149

pulling the wrist into extension, or by grasping round and rotating a thick rod (about 2 inches in diameter) which is prevented from rotating freely by the physiotherapist or by a mechanical device, as in the case of the Wrist Roll Machine.

THE WRIST FLEXORS

Flexor Carpi Radialis, Flexor Carpi Ulnaris and Palmaris Longus flex the wrist with the assistance of Flexor Digitorum Sublimus and Flexor Pollicis Longus. These muscles can be exercised in a manner similar to that used for the Wrist Extensors, but the movement is reversed and it must be remembered that the fingers must be allowed to extend during the movement to avoid limitation of the range.

The Ulnar and Radial Flexors

Flexor and Extensor Muscles combine to produce ulnar and radial flexion or deviation. The Ulnar Flexors are Flexor Carpi Ulnaris and Extensor Carpi Ulnaris, and the Radial Flexors are Flexor Carpi Radialis and Extensor Carpi Radialis Longus and Brevis. Strengthening of all these muscles has already been considered when they work in the capacity of Wrist Flexors and Extensors, but ulnar and radial

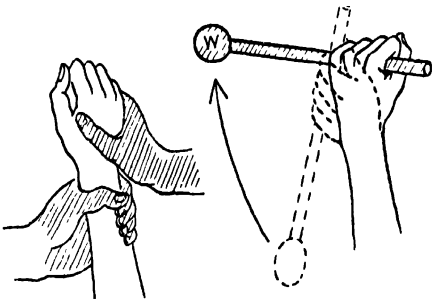


Fig. 150

flexion provide an alternative method of working them and another pattern of co-ordination.

Exercise is carried out with the wrist in mid-position, the hand being in line with the forearm, the position of which is adjusted as required to allow the movement to be performed with gravity eliminated or resisting. Assistance or resistance are usually given manually but a weight or elastic recoil is sometimes useful. Free Exercise can be performed with or without the resistance of gravity.

Muscles which move the Fingers and Thumb

The muscle groups which move or stabilise the fingers and thumb can be worked individually with suitable fixation of adjacent joints and with the physiotherapist's assistance, or resistance, given in the path of the movement. Alternatively varying thicknesses of elastic may be used for assistance or resistance when it is attached to the fingers or thumb by loops or finger-stalls. The functional and free use of the hand as a whole must never be omitted, as the memory of the complex patterns of co-ordinated movement involved in gripping objects and spreading the hand must be retained.

Examples of Free Exercise for the Hand

a. *sitting; Finger and Thumb bending and stretching (use both Hands).*
b. *sitting; Finger and Thumb parting and closing (use both Hands).*
c. *sitting; Palm hollowing with Thumb and little Finger opposition.*
d. *sitting; Palms on table; Finger raising.*

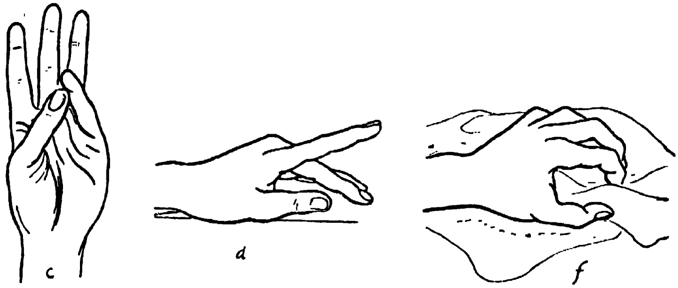


FIG. 151

e. *sitting; throw, catch, squeeze and rotate balls of different sizes in the Hand.*
f. *sitting (Palm facing downwards); collect and spread a towel, sheet of paper, rice or sand which lies on a table.*

Activities. These are very numerous and include most everyday activities in which the hand is used, e.g. using a knife and fork, doing up and undoing buttons, tying shoelaces, opening and shutting doors, using scissors, needle, pen and typewriter. Grasping and holding a variety of objects, such as shopping baskets and tools, and counting money must also be practised. Games such as golf and tennis and playing musical instruments such as a piano and violin provide good exercise.

THE EXTENSORS OF THE HEAD AND NECK

These muscles usually work with the Extensors of the Upper Back, they are the Rectus Capitis Major and Minor, Obliquus Superior, Semispinalis Capitis, Splenius Capitis and Trapezius (upper fibres).

Assisted Exercise for the Extensors of Head and Neck. Assistance can be given manually with the patient in *side lying*, the head being supported in alignment with the trunk either by the physiotherapist's hand or with the help of sling suspension.

Examples of Free Exercise for the Extensors of the Head and Neck

a. *sitting; Head dropping forward and raising to the vertical.*
b *prone lying or prone kneeling; Head dropping forward and raising.*

Resisted Exercise for the Extensors of the Head and Neck. This is given manually in *crook lying* or in *reach grasp stride sitting* (see Swedish Remedial Exercises, No. 20, *Neck Extension (resisted)*, p. 206). *Prone lying* is also a suitable starting position for the patient when strong resistance is required.

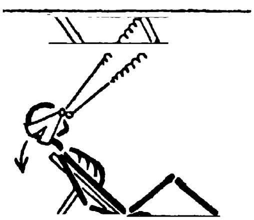


FIG. 152

Spring or weight and pulley resistance can be arranged, but this must not be too strong. Any jarring movement likely to occur as the result of spring recoil as the head returns to the starting position must be avoided, the speed of this part of the movement must be controlled by the Extensor Muscles working eccentrically.

THE FLEXORS OF THE HEAD AND NECK

The Flexors of the Atlanto-occipital Joint are Longus Capitis, Rectus Capitis Anterior and Sternomastoid; Longus Cervicis, the Scaleni and Sternomastoid flex the cervical spine. These two movements can be isolated from each other to some extent.

Assistance for the muscles can be given with one or both of the physiotherapist's hands placed on the occiput with the patient in the *lying* position or a *low half lying*. Alternatively he can assist himself by using his own hands clasped behind the head.

Free exercises are also done from *lying*, the head being lifted and bent forwards till the chin touches the suprasternal notch.

Resistance may be given manually, either on the forehead or under the chin. In the latter case pressure given inadvertently on the larynx must be avoided.

THE SIDE FLEXORS OF THE HEAD AND NECK

The Flexor and Extensor Muscles of one side only work to produce this movement. The Side Flexors are Rectus Capitis Lateralis, Semispinalis Capitis, Splenius Capitis, Sternomastoid and Trapezius (upper fibres).

Assisted Exercise for the Side Flexors of the Head and Neck. Lying with the shoulder girdle fixed is the most suitable position for assisting the action of these muscles. The physiotherapist sits behind the patient clasping her hands under the occiput or on the side of the head over the ears.

Examples of Free Exercise for the Side Flexors of the Head and Neck

a. *prone kneeling; Head side bending (to put ear on Shoulder).*
b. *Arms folded cross, crook or stride sitting; Head side bending.*
c. *side lying; Head raising and lowering.*

These movements can be combined with Trunk side flexion to the same side.

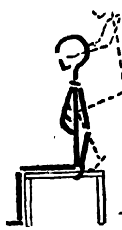


FIG. 153

Resisted Exercise for the Side Flexors of the Head and Neck. Manual resistance is given from *low grasp lying* or *low grasp sitting*, a slight head traction preceding the movement.

THE ROTATORS OF THE HEAD AND NECK

The muscles forming this group are the Obliqus Capitis Inferior, Rectus Capitis Posterior Major, Splenius Capitis of the side towards which the movement takes place and Sternomastoid of the opposite side. Assistance and Resistance to the muscles are given from the same starting positions and with the same grasps that are used for the Head and Neck Side Flexors.

Examples of Free Exercises for the Rotators of the Head and Neck

a. *half low grasp sitting; Head turning with one Arm lifting sideways.*
b. *prone kneeling; Head turning.*
c. *sitting or cross sitting; Trunk bending and turning with Head turning to put ear towards opposite Knee.*

Head rotation often accompanies movements involving Trunk rotation.

THE STERNOMASTOID MUSCLE

The Sternomastoid Muscle of one side bends the head to the same side and rotates it to the opposite side. These movements may be

FIG. 154. Grasp for resisting the action of the Right Sternomastoid Muscel

performed consecutively and a convenient grasp for resistance by the physiotherapist is one in which one of her hands is placed across the vertex of the patient's head while the other hand is cupped under the chin so that the fingers extend above the tempero-mandibular joint. Resistance is given to side flexion with the fingers of the upper hand and to rotation with the fingers of the lower hand.

11

SWEDISH REMEDIAL EXERCISES

THE following exercises performed with manual resistance given by the physiotherapist are based on the Swedish System of Remedial Exercises which was widely used at the beginning of the century. In the light of modern physiological teaching, many of the exercises which were used formerly have now become obsolete. Of those which are still considered to be of value and have been retained, the following examples are given in detail to show a method of describing an exercise and of analysing the movement and the muscle work it provides. The muscle work of the starting position is given elsewhere.

1. *high sitting;* SINGLE KNEE EXTENSION (RESISTED)

This exercise is designed to provide resistance for the Knee Extensors.

The patient sits on a high plinth with the thighs fully supported. The physiotherapist is in a *fallout* position on the side of the leg to be moved; she fixes the thigh with one hand placed four fingers' breadth above the knee, to avoid pressure on the synovial pouch which extends above the patella. Her other hand resists on the anterior aspect of the leg, just above the ankle joint.

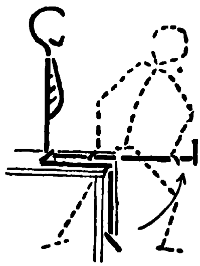


FIG. 155

The knee is extended against resistance to the limit of the range, to ensure innervation of the Vastus Medialis. To make sure that there is no lag, the resisting hand is moved under the heel to give upward pressure. The patient then is instructed to bend the knee slightly to 'unlock' the joint and then to resist while the leg is pressed back to the starting position by the physiotherapist's hand, which has been replaced on the front of the leg.

Analysis of Movement and Muscle Work

For the purpose of description the exercise can be divided into two parts.

Part 1. The knee is straightened against resistance.

There is extension of the knee joint by the Extensors of the Knee (Rectus Femoris, Vastus Medialis, Lateralis and Intermedius) working concentrically in middle and inner range.

Part 2. The patient allows the knee to bend freely for the first few degrees, and then resists as the movement is completed.

There is flexion of the knee brought about by gravity at first and then by pressure of the physiotherapist's hand, the Extensors of the Knee working eccentrically, in the same range as in Part 1, to resist and control the movement.

The axis of movement is frontal and the plane sagittal.

Modifications

Side lying, prone lying and *half lying* are alternative starting positions; in the last two full-range movement can be obtained. Both legs can be worked simultaneously in *prone lying* and *high sitting*, in which case the physiotherapist uses her forearms for fixation and resistance instead of her hands.

Effects and Uses

The Extensors of the Knee are strengthened and the mobility and stability of the joint are maintained or improved. The exercise is used in cases of muscular weakness and instability of the knee. Double Knee Extension with a pillow between the knees and with the ankles held together can be used to strengthen and mould the legs in treating small children with knock knees.

2. *lying;* SINGLE KNEE UPDRAWING AND DOWNPRESSING

This is a resisted exercise designed to work the Flexors of the Hip and the Abdominal Muscles.

The patient lies in the fundamental position on a low plinth and the physiotherapist stands astride, with one hand on the shoulder to fix the trunk and the other above the knee.

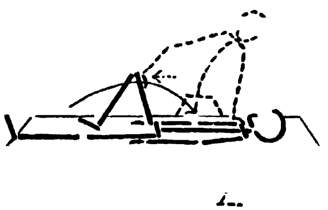


FIG. 156

The knee is drawn up towards the shoulder by the patient against the resistance of the physiotherapist, who moves her hand to the front of the knee to give overpressure at the limit of the range. This hand is then replaced above the knee and the leg is pressed back to the starting position against the patient's resistance. The exercise is usually performed in time with breathing, expiration taking place as the knee is drawn on to the chest.

Analysis of Movement and Muscle Work

Part 1. The knee is bent on to the chest against resistance.

The hip and knee joints are fully flexed, the Flexors of the Hip

(Psoas, Iliacus, assisted by Pectineus, the long head of Rectus Femoris, and Sartorius) work concentrically in nearly full range, only the last few degrees of the outer range being omitted. The Flexors of the Lumbar Spine (Abdominal Muscles, especially Rectus Abdominis) and the Extensors of the stationary Hip (Hamstrings and Gluteus Maximus) work statically to fix the origin of the Hip Flexors on the lumbar spine and pelvis.

Part 2. The patient resists while the knee is pressed down.

The hip and knee joints are extended by the physiotherapist, the movement being resisted and controlled by the Flexors of the Hip working eccentrically. The range and static muscle work are the same as in Part 1.

The knee is bent passively by the weight of the leg, but there is usually some control by the Extensors in the second part of the movement. The axis of movement is frontal and the plane sagittal.

Modifications

A variety of alternative starting positions are suitable. The patient can fix his own trunk as in—

stretch grasp Back against standing
heave grasp lying or half lying

—in which case the physiotherapist's free hand is placed in the lumbar region to control the tendency for the back to hollow and the pelvis to tilt forward when the Flexors of the Hip start to work strongly and their origin is not securely fixed.

Crook lying or *half lying* limit the extent of the movement so that the Hip Flexors work in inner range only.

Both legs can be moved simultaneously in the lying positions, resistance being given either by the physiotherapist's forearm across both knees, or with one hand resisting above each knee when the patient fixes his own trunk. As the pelvis is free to move, once the legs are drawn upwards beyond a right angle the straight Abdominal Muscles work concentrically in middle range to flex the lumbar spine, and as the legs are pressed downwards again the same muscles work eccentrically in the same range.

Effects and Uses

The working muscles are strengthened and the range of joint movement is maintained or improved. The strong contraction of the Abdominal Muscles which takes place when both legs are moved, and the mechanical pressure on the abdomen, stimulate the involuntary musculature of the viscera and assist the circulation in the abdominal cavity. Digestive and excretory functions are improved as the result of the previous effects, and when these have been sluggish this exercise will be useful.

Respiration is hindered by the strong action of the Abdominal Muscles as the descent of the Diaphragm is impeded by the increase in intra-abdominal pressure; the exercise may be unsuitable, therefore, for patients suffering from Respiratory or Heart conditions.

3. *lying;* SINGLE LEG LIFTING AND DOWNPRESSING

The patient keeps the knee straight during this exercise, otherwise it is the same as the previous one. The Flexors of the Hip work at

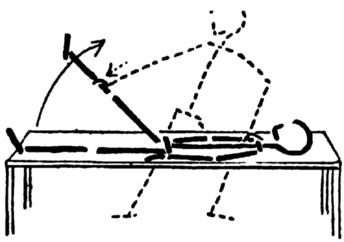


FIG. 157

a considerable mechanical disadvantage due to the length of the weight arm presented by the extended leg, therefore resistance is usually light and may be given either at the knee or on the lower leg.

Analysis of Movement and Muscle Work

This is the same as in the previous exercise except that the Flexors of the Hip work in the middle range only, as the range of flexion is limited by the tension of the Hamstrings. In addition to the strong static work of the Abdominal Muscles and the Extensors of the stationary Hip, the Extensors of the Knee of the moving leg (Vastus Internus, Externus and Intermedius and Rectus Femoris) also work statically.

Modifications

When both legs are lifted simultaneously the resistance of gravity is usually sufficient. In this case the movement may be continued to include flexion of the lumbar spine, during which the straight Abdominal Muscles work concentrically in the first part and eccentrically in the second part of the movement.

Effects and Uses

The muscles work more strongly than in the previous exercise and include the Extensors of the Knee of the moving leg, which work strongly at the limits of the range and especially when resistance is given below the knee.

4. *half lying;* SINGLE LEG UPDRAWING AND DOWNDRAWING

This is similar to Knee updrawing and downpressing with the addition of work for the Knee Flexors.

The patient is supported in *half lying* on a plinth and the physiotherapist, in *walk standing*, in front, grasps behind the ankle with one hand, and above the knee with the other.

The knee is drawn upwards towards the shoulder and the heel towards the buttock against resistance, overpressure is given at the limit of the range, and the leg is then drawn downwards and back to position against the patient's resistance.

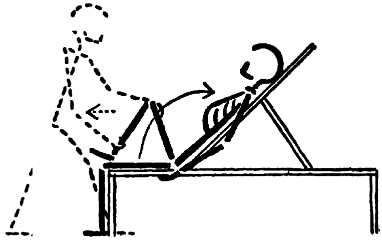


FIG. 158

Analysis of Movement and Muscle Work

Part 1. The hip and knee are fully bent against resistance.

There is flexion at the hip and knee joints brought about by the Flexors of the Hip (Psoas, Iliacus assisted by Pectineus, long head of Rectus Femoris and Sartorius), and the Flexors of the Knee (Hamstrings and Gastrocnemius) working concentrically in inner range. The Flexors of the Lumbar Spine (Abdominal Muscles, especially Rectus Abdominis) work statically to fix the origin of the Hip Flexors.

Part 2. The patient resists and the hip and knee are partially extended.

The hip and knee joints are extended by the physiotherapist, this movement being resisted and controlled by the Flexors of the Hip and Knee working concentrically in inner range. The Flexors of the Lumbar Spine continue to work statically. The axis of movement is frontal and the plane sagittal.

Modifications

In the lying position the range of movement is increased, the Hip Flexors working in middle and inner range and the Knee Flexors in full range.

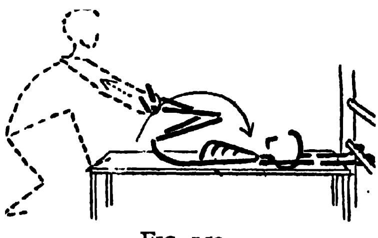


FIG. 159

When both legs are moved simultaneously, the patient fixes the trunk by grasping the ribstalls behind the plinth (*stretch grasp lying*), and the physiotherapist stands at the foot of the plinth and grasps round the ankles. As the pelvis is free to move, the Flexors of the Lumbar Spine work concentrically and eccentrically in inner range as in double *Knee updrawing and downpressing*.

Effects and Uses

These are similar to those of *Knee updrawing and downpressing*, but the muscles work more strongly, there is additional work for the Knee Flexors and an additional joint to control.

5. *low grasp Back against standing;* SINGLE LEG FORWARD DRAWING AND BACKWARD CARRYING

This exercise is used to work the Extensors of the Hip.

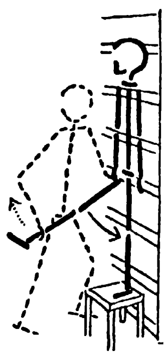


FIG. 160

The patient stands erect with his back to the wall-bars and usually grasps a bar at a convenient height, the weight of the body is then transferred to one leg only. The physiotherapist, in stride standing at the side, supports across the pelvis, on the anterior superior spines, with one forearm and with the other hand grasps round the ankle.

The physiotherapist draws the leg forward with the knee straight to about 80° from the vertical, while the patient resists. The patient then carries it back into line with the trunk against resistance.

Analysis of Movement and Muscle Work

Part 1. The leg is drawn forward as the patient resists.

There is flexion in the hip joint of the moving leg, brought about by the physiotherapist and resisted and controlled by the Extensors of the Hip of the moving leg (Gluteus Maximus and Hamstrings) working eccentrically in middle range, only the last few degrees of the inner range being omitted. The Back Extensors work statically to fix the origin of these muscles, and the Knee Extensors of the same leg may work slightly towards the end of the movement, if the tension of the Hamstrings is considerable.

Part 2. The patient draws the leg back to regain the starting position, against resistance.

There is extension in the hip joint of the moving leg, the same muscles work as in Part 1, but the Extensors of the Hip work concentrically in the same range in this instance.

The muscle work of the starting position is considerable (see *half standing*, p. 242); the Extensors of the Hip and Knee of the standing leg work strongly to resist flexion of these joints, which tends to occur as the result of tension on the Hamstrings when the leg is lifted forwards.

Modifications

High standing is often convenient from the point of view of the physiotherapist and it tends to improve the patient's posture. When *lying* is used as a starting position the static muscle work is obviously reduced to a minimum.

Effects and Uses

This is an easy exercise used to strengthen the working muscles and to improve the postural alignment of the trunk and lower limbs.

6. *lying;* SINGLE LEG OUTSTRETCHING

The Extensors of the Hip and Knee are worked concentrically and at the same time in this exercise.

With the patient lying, the physiotherapist puts one hand under the thigh, just above the knee, and grasps round the heel with the other, supporting the sole of the foot on her forearm.

The patient is instructed to relax and the hip and knee are fully bent passively. Towards the end of the movement the hand below the thigh glides round the outer side of the knee to rest below and in front of the knee to give overpressure at the limit of the range. The patient extends the hip against resistance to press the heel towards the plinth, and then further extends the hip and the knee towards the foot of the plinth to regain the starting position. As the knee straightens the physiotherapist again moves the hand at the knee to its original position under the thigh, to prevent jarring during the final degrees of extension.

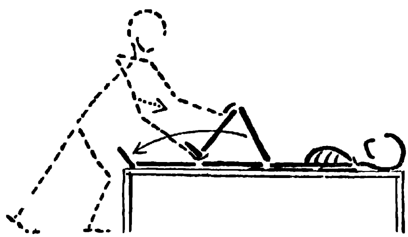


FIG. 161

Analysis of Movement and Muscle Work

Part 1. The leg is bent on to the chest passively, the hip and knee joints are fully flexed and there is no muscle work.

Part 2. The leg is extended against resistance.

There is extension in the hip and knee joints; the Extensors of the Hip and Knee work concentrically, those of the hip in outer and middle range and those of the knee in full range. The axis of movement is frontal and the plane sagittal.

Modifications

The Extensors of the Hip work in outer range, only when the movement is taken from *half lying*.

Effects and Uses

This is a relatively easy exercise in which the Extensors of the Hip and Knee are strengthened and work together to produce the natural extension movement of the leg. It is useful for weak patients as a preliminary to weight-bearing.

7. *wing kneel sitting;* TRUNK RAISING AND DOWNPRESSING

This exercise also works the Extensors of the Hips and Knees.

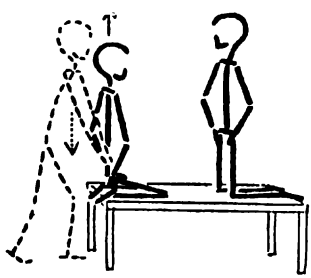


FIG. 162

With the patient in *wing kneel sitting* on the end of a low plinth, the physiotherapist stands behind and puts her hands over the patient's hands or on the shoulders.

The physiotherapist resists while the patient raises to kneeling and then she presses down to regain the starting position while the patient resists, the trunk being held vertical throughout the exercise.

Analysis of Movement and Muscle Work

Part 1. The patient raises to kneeling against resistance.

There is extension in the hip and knee joints produced by the Extensors of the Hip working in middle range and the Extensors of the Knee in outer range.

Tension of the long head of Rectus Femoris, as that muscle is stretched over the flexed knee joint, tends to tilt the pelvis forward and hollow the back as the hips are extended. To counteract this the straight Abdominal Muscles work statically.

Part 2. The physiotherapist exerts downward pressure to regain the starting position as the patient resists.

There is flexion in the hip and knee joints, brought about by this pressure which is resisted and controlled by eccentric work of the same muscles as in Part 1 in the same ranges. The movement takes place round a frontal axis on a sagittal plane.

In addition to the muscles used to keep the trunk erect, the Dorsiflexors (Tibialis Anterior, Flexors Hallucis and Digitorum Longus and Peroneus Tertius) work statically to stabilise the body and to keep the balance.

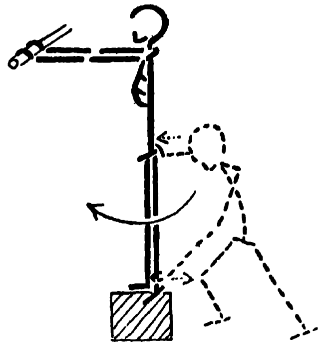
Effects and Uses

The working muscles are strengthened and the maintenance of the correct posture of the trunk during movement of the lower limbs can be trained and observed.

8. *reach grasp high half standing;* SINGLE LEG BACKWARD DRAWING AND FORWARD CARRYING

This exercise involves tilting of the pelvis and works the Extensors of one Hip, the Flexors of the other and the Abdominal Muscles.

The left leg is taken to be the moving leg for the purpose of description. The patient stands on a stool facing a horizontal bar or wall-bars which he grasps at shoulder height with the arms straight. The weight is then transferred on to the right leg only (see p. 145). The physiotherapist in *fallout standing* is behind and to the right, places her near hand immediately above the left hip joint and



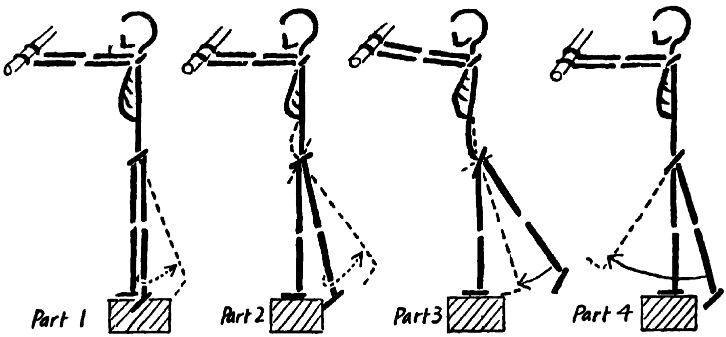


FIG. 163

grasps round the front of the left ankle with the other.

The left leg is drawn backward, with the knee straight, to an angle of about 45° against the patient's resistance, and then he is instructed to carry it forwards to a corresponding angle as the physiotherapist resists.

Analysis of Movement and Muscle Work

It is convenient to divide the exercise into four parts.

Part 1. The leg is drawn backward for about 15° only, as the patient resists.

There is extension in the left hip joint to the limit of the anatomical range; it is produced by the physiotherapist and controlled and resisted by the Flexors of the left Hip working eccentrically in outer range.

Part 2. The leg is drawn still further backward as the patient resists.

As no further movement in the left hip joint is possible, movement is transferred to the right hip joint and the lumbar spine to tilt the pelvis forwards, and so allow the leg to be lifted further. To achieve this there is flexion in the right hip joint and extension in the lumbar spine, these movements being produced by the physiotherapist and controlled and resisted by the Extensors of the right Hip and the Flexors of the Lumbar Spine, working eccentrically in a small part of their middle range.

Part 3. The leg is carried forwards to within 15° of the vertical, against resistance.

This movement is just the reverse of that in Part 2 as the pelvic tilt is restored to the normal angle. There is extension in the right hip joint and flexion of the lumbar spine, brought about by the Extensors of the right Hip and the Flexors of the Lumbar Spine working concentrically in the same range as previously.

Part 4. The leg is carried further forward into line with the body and beyond.

Movement now returns to the left hip joint and there is flexion of this joint produced by the Flexors of the left Hip working concentrically in outer range.

Apart from the muscle work of the starting position which must be maintained throughout the exercise, the Extensors of the left Knee work statically and quite strongly. Movement throughout the exercise takes place about a frontal axis and in a sagittal plane.

Effects and Uses

The working muscles are strengthened, and the postural control of the upper part of the body is trained.

9. *crook lying;* KNEE PARTING AND INPRESSING

This exercise works the Abductors and Lateral Rotators of the Hip.

The patient lies with the knees bent, so that the feet rest flat on the plinth. The physiotherapist stands to the side and level with the patient's feet and puts one hand on the outer side of each knee.

The physiotherapist resists as the knees are parted and then she presses them back to the starting position while the patient resists.

Analysis of Movement and Muscle Work

Part 1. The patient parts the knees against resistance.

There is abduction and lateral rotation in the hip joint brought about by the Abductors of the Hip (Gluteus Medius and Minimus and Tensor Fascia Lata) and the Lateral Rotators of the Hip (Piriformis, Quadratus Femoris, Obturators Internus and Externus, and Gemellus.

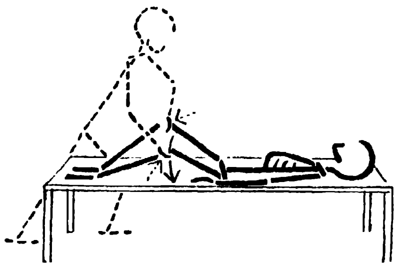


FIG. 164

Superior and Inferior) working concentrically in inner range. Gluteus Maximus also works strongly.

Part 2. The knees are pressed together as the patient resists.

There is adduction and medial rotation in the hip joints, the movement being resisted and controlled by the eccentric work of the same muscles which worked in Part 1, and in the same range.

Modifications

The exercise can also be done in *crook half lying*, and the legs can be moved singly, in which case the one which is stationary is fixed in the starting position by the physiotherapist's hand cupped over the knee, to prevent any lateral rolling of the pelvis.

Effects and Uses

The working muscles are strengthened and it may be used for general strengthening of those round the hip joint, and to gain relaxation of the Adductors.

10. *lying;* LEG PARTING AND INPRESSING

The Abductors of the Hip work in this exercise, and there is passive tension on the lateral structures of the knee joint.

The physiotherapist stands at the end of the plinth and grasps round the outer side of the patient's ankle and gives traction.

The patient parts the legs against resistance, keeping the knees extended and pressing them apart as much as possible. Lateral rotation at the hip joint should be avoided by keeping the feet vertical.

The physiotherapist then presses the ankles together to regain the starting position, while the patient resists.

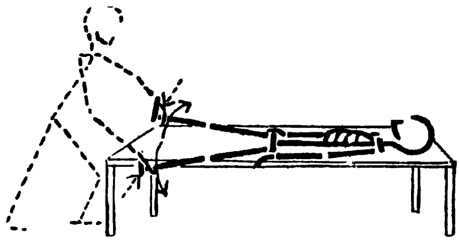


FIG. 165

Analysis of Movement and Muscle Work

Part 1. The patient parts the legs against resistance.

There is abduction in both hip joints, the Abductors of the Hip working concentrically in inner range to bring about the movement against resistance. The Extensors of the Knees, especially Vastus Medialis, work statically.

Part 2. The legs are pressed together while the patient resists.

There is adduction in the hip joints, brought about by the physiotherapist, resisted and controlled by the Abductors of the Hips working eccentrically in inner range. The axis of movement is sagittal and the plane frontal.

Modifications

When one leg, only is moved in the lying position, the pelvis is fixed by positioning the stationary leg in full abduction, and the physiotherapist stands at the side of the moving leg resisting and supporting the leg by grasping the ankle from the lateral side with one hand and the knee with the other. *Half lying* may also be used for the movement of one or both legs.

In *reach grasp high half standing* only one leg can be moved but the Abductors of both Hips work as the pelvis tilts laterally to procure an apparent increase in range.

Analysis of Movement and Muscle Work of reach grasp high half standing; single Leg parting and inpressing

The exercise can be divided into four parts. In Parts 1 and 2 the patient lifts the leg against resistance. In Parts 3 and 4 it is pressed back to the starting position.

Part 1. There is abduction in the hip joint of the moving leg (to about 30°), the movement being brought about by the Abductors of this Hip working concentrically in inner range.

Part 2. As the limit of abduction of the moving leg has now been reached, movement is transferred to the hip joint of the standing leg, and the pelvis is tilted laterally by abduction in this joint, with the result that the moving leg is lifted higher. The movement is brought about by the Abductors of the Hip of the standing leg working with reversed origin and insertion and the Lumbar Side Flexors on the opposite side to keep the trunk upright. The Abductors work concentrically in inner range and the Lumbar Side Flexors concentrically in middle range, while the Abductors of the Hip of the moving leg work statically.

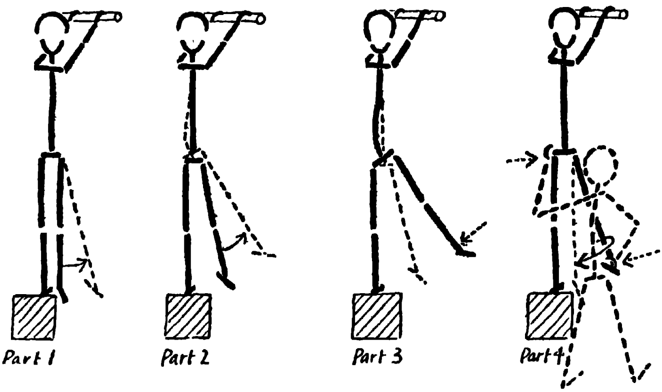


FIG. 166

Part 3. This is the reverse of Part 2. The pelvis is straightened as the leg is pressed inwards by the physiotherapist. The movement of adduction in the hip of the standing leg is resisted and controlled by the Abductors of the Hip of that leg and the Lumbar Side Flexors of the opposite side both working eccentrically in the same ranges as in Part 2. The Abductors of the moving leg continue to work statically.

Part 4. This is the reverse of Part 1. Movement now returns to the hip of the moving leg. There is adduction in this joint produced by the physiotherapist and resisted and controlled by the Abductors working eccentrically in inner range.

Effects and Uses

These exercises strengthen the working muscles which are frequently weakened as the result of the typical adduction deformity arising in many hip conditions. Passive stretching of the lateral structures of the knee joint, in addition to the strengthening of the working muscle, makes it suitable, in the non-weight-bearing positions, for children with knock knees. In *reach grasp high half standing*, the erect posture is maintained throughout the movement, which is valuable training both in posture and the control of the pelvic tilt in walking.

11. *crook lying;* KNEE CLOSING AND OUTDRAWING

This exercise is designed to work the Adductors and Medial Rotators of the Hips, and the muscles of the pelvic floor.

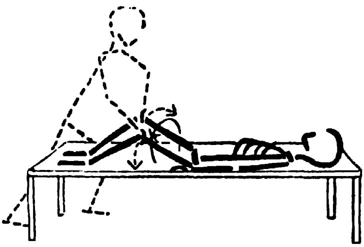


FIG. 167

The patient lies with the knees bent and apart, so that the feet are together and rest on the plinth, and the physiotherapist stands at the side and, pronating her forearms, puts one hand on the inner side of each of the patient's knees.

The patient brings the knees together against the physiotherapist's resistance, and then resists as they are drawn apart.

Analysis of Movement and Muscle Work

Part 1. The patient closes the knees against resistance.

There is adduction and medial rotation at the hip joint, the movement being produced by the Adductors of the Hip (Adductores Magnus, Longus, and Brevis assisted by Pectineus) and the Medial Rotators of the Hip (Tensor Fascia Lata, Gluteus Medius and Minimus) working concentrically in outer range.

Part 2. The knees are drawn apart again as the patient resists.

There is abduction and lateral rotation in the hip joints, the movement being resisted and controlled by the Adductors of the Hip and the Medial Rotators, working eccentrically in outer range.

Modifications

The exercise may also be done from *crook half lying* and *crook lying with Pelvis lifted*, or from *crook lying* it may be combined with *Pelvis lifting and lowering*, the pelvis being lifted from the plinth as the knees are brought together. One hip only may be moved from *crook lying* or *crook half lying*, in which case the stationary leg is fixed to prevent movement of the pelvis.

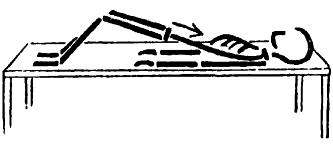


FIG. 168

Effects and Uses

The working muscles are strengthened. It is thought that contraction of the muscles of the pelvic floor (Levator Ani, Coccygeus) is associated with that of the Adductors and Extensors of the Hip (especially Gluteus Maximus), and this exercise is therefore frequently used as a means of gaining this contraction when these muscles are stretched and weakened as in visceroptosis or after childbirth. Elevation of the pelvis, preferably by the contraction of the Hip Extensors, not only reinforces the effect but reduces the pressure of the viscera on the pelvic floor.

12. *stride lying;* LEG CLOSING AND OUTDRAWING

This exercise works the Adductors of the Hip and the muscles of the pelvic floor.

The patient lies with the legs apart and the physiotherapist stands at the end of the plinth and puts one hand on the inner side of each of the patient's ankles. Owing to the length of the leg, the mechanical advantage gained by the physiotherapist is considerable, and strong resistance can be given, but the leverage can be reduced by giving resistance nearer to the hip joints, i.e. just below the knee.

The patient brings the legs together against resistance and tries to brace the pelvic floor; the legs are then drawn apart as the patient resists.

Analysis of Movement and Muscle Work

There is no rotation during the movement, otherwise it is the same as for *Knee closing and outdrawing*.

Modifications

The exercise can also be done in *half lying* or *hanging* and one leg only may be moved in *lying*, *half lying* or *reach grasp high half standing*. In the latter position lateral tilting of the pelvis accompanies the movement, but the Adductors and Lumbar side Flexors on the same side work in this connection, instead of the Abductors and Lumbar side Flexors of the opposite side as in *Leg parting and inpressing* (see p. 194).

Effects and Uses

These are the same as for *Knee closing and outdrawing*, but in addition, tension on the medial structures of the knee joint during the movement may be utilised in treating children with bow legs.

13. *relaxed stoop stride sitting;* BACK EXTENSION (CONTROLLED)

This exercise is designed to work the Back Extensors concentrically and eccentrically, so that the spine is extended progressively (vertebra by vertebra). The physiotherapist controls the movement but does not resist it.

The patient sits on a stool and relaxes forwards to round the back and the physiotherapist stands astride at one side, placing one hand on the sacrum and the other on the back of the neck, with fingers pointing down the spine.

The movement begins with a straightening of the lower back and continues progressively upward as the physiotherapist's hand is stroked up the spine, the head being raised last. Slight head traction can be given in the erect position to give emphasis to the position.

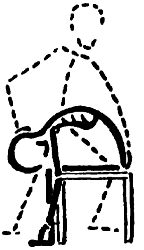


FIG. 169

To return to the starting position the movement is reversed, the head bending first.

Analysis of Movement and Muscle Work

Part 1. The trunk and head are raised.

Extension takes place at the hip, intervertebral and atlanto-occipital joints by the action of the Hip Extensors (Gluteus Maximus), Back Extensors (Sacrospinalis), Neck Extensors (Splenius and Semispinalis Capitis), and the Extensors of the atlanto-occipital joint (Sub-occipital Muscles, Neck Extensors and Trapezius, upper fibres), all working concentrically in outer and middle range. In the erect position the Flexors of the Lumbar Spine, the Pre-vertebral Neck Muscles and the Retractors of the Scapulae work statically.

Part 2. The head and trunk relax forward progressively.

The same muscles work as in Part 1, but eccentrically, in the same range to control the movement which is initiated by gravity.

The axis of movement is frontal and the plane sagittal.

Modifications

The exercise can be performed with pressure between the scapulae at the completion of Part 1, in which case the physiotherapist stands in front of the patient and resists the movement by firm pressure given with her hand stroking up the spine from the sacrum to the mid-thoracic region. In *reach grasp relaxed stoop sitting* or *reach grasp thigh support relaxed stoop stride standing* strong resistance can be given through the arms by the physiotherapist who sits in front and steadies herself by counter-pressure of one foot on the stool or bar. The Scapula Retractors also work strongly when the exercise is done in this manner.

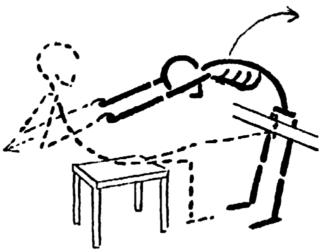


FIG. 170

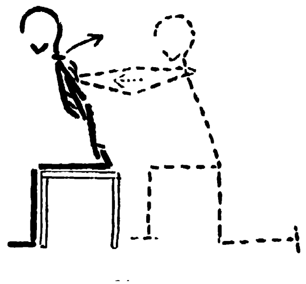
Effects and Uses

The working muscles are strengthened, as their contraction is controlled, to move all parts of the spine.

The progressive extension to the upright position helps the patient to attain the co-ordination required for good posture and the exercise is widely used in the treatment of spinal curvatures and poor posture. The thorax and abdomen are compressed during flexion and this assists expiration when the exercise is done in time with breathing. For patients suffering from emphysema emphasis is laid on this phase. In this case no resistance is given, the movement being merely controlled.

14. *wing stoop stride sitting;* BACK RAISING (RESISTED)

This exercise is designed to work the Back Extensors and Scapula Retractors statically to control the posture of the trunk during movement at the hip joints.



With the patient in *wing stoop stride sitting*, the physiotherapist kneels behind and places both hands over the mid-thoracic spine.

The physiotherapist then resists, as the patient, keeping the back straight throughout, raises the trunk to the upright position. To regain the starting position the movement is reversed, the physiotherapist pressing the trunk forwards as the patient resists.

Analysis of Movement and Muscle Work

Part 1. The patient raises the trunk against resistance.

There is extension at the hip joints by the Extensors of the Hip (Gluteus Maximus and Hamstrings) working concentrically in middle range. The trunk is kept in alignment by the Back Extensors, the Scapula Retractors, the Neck Extensors, the Pre-vertebral Neck Muscles and the Flexors of the Lumbar Spine, all of which work statically throughout the exercise.

Part 2. The physiotherapist presses the trunk forward as the patient resists.

There is flexion of the hip joints, resisted and controlled by the Hip Extensors working eccentrically in middle range.

Movement in the lumbar spine should be avoided as far as possible, by allowing only a small range of movement in the hip joints, but it is inevitable if the Hamstrings are tight. The axis of movement is frontal and the plane sagittal.

Modifications

The difficulty of the exercise can be increased by altering the position of the arms, e.g. *yard* or *stretch*.

Effects and Uses

The working muscles are strengthened and the postural control of the trunk is trained, therefore the exercise is used mainly for patients with postural defects.

15. *wing relaxed high ride sitting;* TRUNK RAISING TO THE VERTICAL AND FORWARD BENDING

The Flexors of the Spine work in inner range during this exercise

The patient sits astride with the thighs strapped to a high plinth with the back relaxed and rounded so that the head is drawn in towards the umbilicus. The physiotherapist stands behind, and grasps under the arms so that her hands rest on the front of the patient's shoulders. A pillow is supported between her and the patient's back.

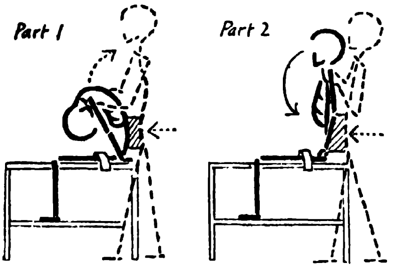


FIG. 172

The physiotherapist presses her trunk forwards against the pillow and bends her arms to raise the patient to the upright position as the latter resists. The head is lifted into alignment with the trunk to complete the movement. The patient then bends the head forward and rounds the back against resistance. Movement at the hip joints is minimised to obtain maximum flexion of the spine.

Analysis of Movement and Muscle Work

Part 1. The patient resists as the spine is extended.

There is extension of the spine produced by the physiotherapist, resisted and controlled by the Flexors of the Spine (straight Abdominal Muscles and Gluteus Maximus) working eccentrically in their inner range. In addition, there is eccentric work for the Scapula Protractors as the shoulders are drawn back, and as the arms are fixed Pectoralis Major also works. The Flexors of the Hip work statically or in small range. The head is lifted freely by the Neck and Head Extensors working concentrically in outer range.

Part 2. The patient regains the starting position against resistance.

The trunk is flexed by the Flexors of the Spine, working concentrically in inner range. The Flexors of the Hip work as above, Flexion of the head is free, the Flexors initiating the movement, which is then controlled by the Extensors, until finally the Flexors work again to draw the head well in.

The axis of movement is frontal and the plane sagittal.

Effects and Uses

The working muscles are strengthened and the abdominal viscera are compressed. The exercise is therefore used to improve abdominal control and to strengthen these muscles for patients with lordosis and weak Abdominal Muscles. The strong contraction of the abdominal wall is thought to have a stimulating effect upon the underlying involuntary musculature of the viscera, and the intermittent compression of the abdominal contents assists the portal circulation. An improvement in digestion and excretion may therefore result.

Respiration is hindered during the exercise as the descent of the Diaphragm is impeded by an increase in the inter-abdominal pressure, due to the strong contraction of the abdominal wall and the position of the thorax. The exercise can be modified to assist expiratory breathing, in which case the patient raises the trunk freely during inspiration, and only the second part of the exercise is performed against resistance, during expiration.

16. *wing close sitting;* TRUNK ROTATION (RESISTED)

This exercise is designed to work the Trunk Rotators in outer range.

The physiotherapist stands in front of the patient and steadies the latter's knees with her own. One hand is placed in front of one of the patient's shoulders and the other behind the other shoulder.

The patient is instructed to 'breathe in', and then to 'breathe out' and resist, as the physiotherapist rotates the trunk to one side. The patient then breathes 'in' and turns forward against resistance. The exercise is repeated to the opposite side.

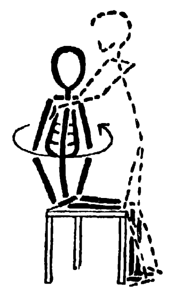


FIG. 173

Analysis of Movement and Muscle Work

Part 1. The trunk is turned to one side by the physiotherapist as the patient resists.

There is rotation in the spine (chiefly the thoracic region) produced by the physiotherapist, resisted and controlled by the Trunk Rotators (the Internal Oblique Abdominis and Multifidus on one side, and the External Oblique and Rotatores on the other) working eccentrically in their outer range. As resistance is given on the shoulders the Scapula Retractors on one side and the Protractors on the other also work to reinforce the movement.

Part 2. The patient turns forward against resistance.

The spine rotates to the opposite side, the movement being produced by the same muscles as in Part 1 working concentrically and in outer range.

Effects and Uses

The working muscles are strengthened and the rotatory mobility of the spine is maintained or improved. The exercise is used as a general trunk exercise when the muscles in question are weak, and in cases of partially mobile scoliosis, when it is performed to one side only. Breathing is hampered in the turn position, therefore the movement is performed with expiration as this position is reached.

17. *yard Palms forward stride sitting;* ARM FORWARD DRAWING AND PARTING

This exercise is designed to work the Retractors of the Scapulae and the Extensors of the Shoulders.

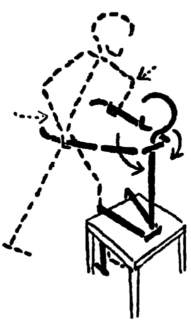


FIG. 174

The patient sits astride with arms held horizontally and the palms turned forwards. The physiotherapist, in *walk standing*, in front of the patient, grasps over and behind the wrists or elbows, according to the amount of resistance required.

The physiotherapist draws the arms forward to *reach* position against the patient's resistance, then the latter carries the arms back to the starting position while the physiotherapist resists. The arms must be kept horizontal throughout. The exercise is usually done with controlled breathing, inspiration with arm parting and expiration with forward drawing.

Analysis of Movement and Muscle Work

Part 1. The arms are drawn forward as the patient resists.

There is flexion in abduction at the shoulder joints and forward movement of the scapula round the chest wall. The movement is brought about by the physiotherapist, resisted and controlled by the Extensors of the Shoulder (Deltoid, posterior fibres, Teres Major, Latissimus Dorsi) and the Retractors of the Scapulae (Trapezius, middle and lower fibres, Rhomboid Major and Minor) working eccentrically in inner range. The Extensors of the Elbow work statically to keep the joint straight.

Part 2. The arms are parted by the patient against resistance.

There is extension in abduction in the shoulder joint and retraction of the scapulae, brought about by the Extensors of the Shoulder and the Retractors of the Scapulae working concentrically in inner range. The axis of movement is vertical and the plane horizontal.

Modifications

The exercise can be done in a variety of starting positions, many of which decrease the strength of the exercise and the control required to maintain the starting position, by support or by altering the relationship of the body with regard to gravity. In every case the arms remain at right angles to the body throughout the exercise. Alternative starting positions which are suitable are, *half lying*, *high ride sitting* and *prone lying*.

Effects and Uses

The working muscles are strengthened and posture and control of the upper back is improved, making the exercise useful in the treatment of postural deformities, and other conditions in which the Upper Back Muscles and Extensors of the Shoulders are weak. Inspiration is assisted mechanically, to a slight extent, as the arms are parted and the back is braced.

18. *yard Palms upward stride sitting;* ARM LIFTING AND DOWNPRESSING

The Abductors of the Shoulder and Lateral Rotators of the Scapula work in this exercise.

The patient sits on a stool with arms lifted and palms turned upwards. The physiotherapist stands behind in *step standing*, controlling the position of the back with her knee, and grasping round the patient's wrists, or higher up the arms, according to the amount of resistance required.

Traction may be given during the exercise, in which case the patient lifts the arms to the stretch position against resistance, and following traction in elevation, resists as the physiotherapist presses the arms down again to the starting position. Controlled breathing usually accompanies the movement, inspiration with lifting and expiration with downpressing, to prevent the patient holding the breath throughout.

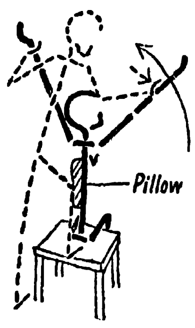


FIG. 175

Analysis of Movement and Muscle Work

Part 1. The patient lifts the arms against resistance.

There is abduction in the gleno-humeral joint and lateral rotation of the scapula at the sterno-clavicular and acromio-clavicular joints. The muscles which work to produce the movement are the Abductors of the Shoulder, Deltoid concentrically in inner range and then statically, Supraspinatus statically throughout, and the Lateral Rotators of the Scapulae (Upper and Lower fibres of Trapezius and Serratus Anterior) working concentrically in inner range.

Part 2. The arms are pressed downwards against the patient's resistance.

There is adduction in the gleno-humeral joint and medial rotation of the scapula. The movement is produced by the physiotherapist's pressure, resisted and controlled by the same muscles as in Part 1, working eccentrically in the same range.

Some degree of forward rotation of the scapula inevitably accompanies elevation. The axis of the movement as a whole is sagittal and the plane frontal.

Modifications

The range of movement can be extended by starting the exercise in *stride sitting* with the arms laterally rotated, in which case the muscles work in practically full range. Alternatively, the muscles can be worked in outer range by starting from the previous position and lifting to the horizontal.

When the exercise is used for one arm only, the arm is bent and the shoulder girdle fixed by manual pressure, so that movement is localised to the gleno-humeral joint and the working muscles are the Abductors of that joint.

Effects and Uses

The working muscles are strengthened and the movement of elevation is maintained and controlled. Strong static work for the upper back muscles, in the role of synergists and fixators, and traction in elevation, improves the position of the thorax and assists inspiration mechanically. The exercise is used in the late treatment after shoulder injuries and for spinal deformities and poor posture.

19. *bend half lying;* ARM STRETCHING UPWARD AND DOWNPRESSING

This exercise is designed to work the muscles which elevate the arms through abduction and also the Extensors of the Elbows.

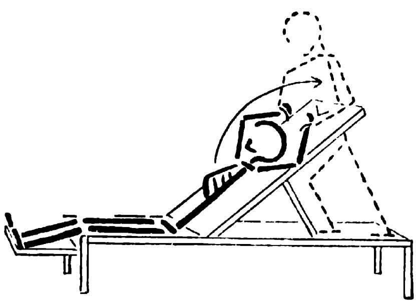


FIG. 176

From *half lying* the patient is instructed to stretch the arms above the head and turn the palms forwards. The physiotherapist stands behind on the platform of the plinth, and grasps the patient's hands from the ulnar side with a thumb grasp, making sure that the palms of the patient's hands are still facing forwards.

Traction is given and the patient's arms are adducted and flexed at the elbow passively in such a way that they are kept in contact with the plinth behind throughout the movement. The patient then elevates the arms and stretches the elbows against resistance, still keeping contact with the plinth behind; traction is given at the end of the movement, and then the arms are pressed back to the starting position by the physiotherapist, as the patient resists.

Analysis of Movement and Muscle Work

Part 1. The patient stretches the arms upwards against resistance.

There is abduction at the gleno-humeral, lateral rotation of the scapula at the sterno-clavicular and acromio-clavicular joints, and extension of the elbow. The Abductors of the Shoulder, the Lateral Rotators of the Scapula and Extensors of the Elbow work concentrically in full range. The first two groups work together in their natural sequence throughout the movement.

Part 2. The arms are pressed downwards against the patient's resistance.

There is adduction at the gleno-humeral joint, medial rotation of the scapula and flexion of the elbow, the movement being produced by the physiotherapist's downward pressure, resisted and controlled by the eccentric work of the same muscles that worked in Part 1 and in the same range.

Modifications

The exercise can be performed from a wide variety of starting positions. There is a tendency for the back to hollow in *half lying*, *lying* (*with Feet fixed*) and *sit lying*, but this is countered by the pull of the Hamstrings in such positions as *crook sitting* and *stoop stride sitting* and reduced in *stride sitting* and *crook lying*.

In *stoop stride sitting* the physiotherapist stands in front and above, and with her arms in line with those of the patient, grasps under the wrist to help support the arms.

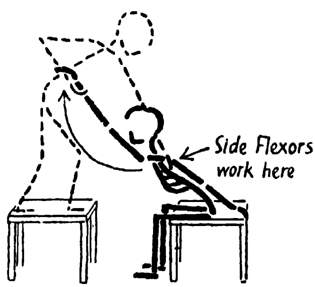


FIG. 177

When one arm is elevated, the final stretch results in a trunk side flexion chiefly in the thoracic region, in an effort to augment the movement in the shoulder and shoulder girdle joints. This movement is best observed or felt by the physiotherapist when *stoop stride sitting* or, in the case of a strong patient, *leg prone lying* is used as a starting position (Fig. 177).

Effects and Uses

The exercise strengthens the working muscles and ensures full-range movement in the joints concerned. It is used for general strengthening of the arms and to teach control and posture of the upper back. The thorax is expanded and the spine stretched during traction in elevation giving the kyphotic patient the feeling of a correct position. The tendency to hollow the back in some positions is utilised in the treatment of flat back or lumbar kyphosis.

When one arm is used and elevation stressed, the action of the Thoracic Side Flexors on the opposite side from the moving arm provides a means of localising the movement to a specific area and of working these muscles strongly in their inner range. It is therefore used in the treatment of some cases of scoliosis.

20. *crook lying;* NECK EXTENSION (RESISTED)

This exercise works the Extensors of the cervical spine and the atlanto-occipital joint, often with control exerted by the Pre-vertebral Neck Muscles.

The crook lying position is used to provide fixation for the shoulders and trunk. The physiotherapist sits behind the patient's head, resting

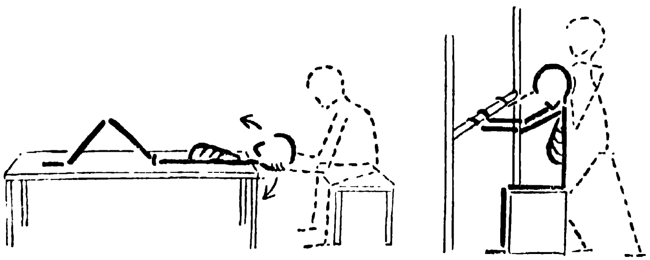


FIG. 178

her elbows on her knees and supporting the patient's head in her hands, with the fingers clasped. The head is flexed passively, and the patient is instructed to press it backwards and downwards into full extension. Resistance is then offered by the patient as the head is raised and bent forward. Alternatively, the patient may draw the chin in first and then carry the head and neck backwards as a whole.

Analysis of Movement and Muscle Work

When the head and neck are pressed backwards as far as possible, there is extension at the atlanto-occipital joints and in the cervical spine, followed by flexion of these joints, as the head is pressed upwards and forwards.

If, however, the chin is drawn in first, a staircase movement occurs, during which each vertebra and the occipital bone is drawn backwards on the one below it until the bones are in alignment, and then the neck and head are drawn backwards as a whole, on the thoracic spine. (This staircase movement is similar to the lateral movement of the whole head, which is a feature of the traditional Indian Dance.)

Part 1. The head is extended against resistance.

The Extensors of the Head and Neck (Splenius and Semispinalis Capitis and the Sub-occipital Muscles) work concentrically in full range, during simple extension, but when the head and neck are carried back together the Sub-occipital Muscles appear to be replaced by the Pre-vertebral Neck Muscles.

Part 2. The head is bent forward against the patient's resistance.

The same muscles work as in Part 1 in the same range but eccentrically. The axis of movement is frontal and the plane sagittal.

Modifications

The exercise can be done with the patient in *reach grasp sitting*, the physiotherapist resisting with one hand cupped on the back of the head and the forearm resting on, and stabilising, the thoracic spine. Movement in the physiotherapist's wrist controls the exercise, as she steadies herself by grasping with the other hand the same bar or wall-bar on which the patient's hands are resting (see Fig. 178).

Effects and Uses

The working muscles are strengthened, and the posture of the head is improved when it is carried into alignment with the trunk. The exercise is used for patients with weak muscles and poor posture. Strong work for the Neck Muscles increases their blood supply and is therefore depletive to the head; assuming that the additional blood in the muscles is drawn from the cranium, relief of headache from congestion may result.

12

PROPRIOCEPTIVE FACILITATION

A Method of Neuromuscular Re-education

By MONICA MARTIN JONES, M.C.S.P.

THIS chapter is an introduction to the method of re-education of movement based on the present-day knowledge of the neuromuscular system, which was devised by Dr Kabat and Miss Knott at the Kabat-Kaiser Institute in California between 1945 and 1954. It uses patterns of movement which are based on natural movement, and through stimulation of the proprioceptors these actions are facilitated. The system also makes use of higher reflex activity, both the equilibrium and the righting reflexes.

PATTERNS OF MOVEMENT

The patterns of movement which have been chosen are both the primitive type and those which are controlled by the higher motor centres. The primitive type consists of either flexion or extension of all the joints of one limb, as seen in the withdrawal or thrust movement in the leg. The higher patterns of movement which need integration of the Central Nervous System and have been gradually developed, are more complex, and will allow flexion of one joint and extension of another as seen in walking, when there is extension of the knee and dorsiflexion of the foot. These higher patterns are more functional, and most of the patterns taught in this system of re-education are of this type. When choosing a pattern of movement in treatment, the age of the patient must be considered.

In this method of re-education only multiple joint movements or mass movement are used. For instance in the re-education of a muscle group such as the hip flexors, instead of isolating the movement to the hip joint, the mass movement will consist of flexion, adduction and lateral rotation of the hip, flexion of the knee and inversion and dorsiflexion of the foot. This pattern of movement is used in walking when the moving leg is brought forward. The reason for using such a mass pattern is that it is more natural to move in this way. As Hugling Jackson said: 'Motor centres know nothing of muscles; they only know of movement.'

Diagonal Planes

All the movements take place in diagonal planes. These planes cut across both the frontal and sagittal planes and have been chosen because both the glenoid cavity and acetabulum face forwards and laterally, allowing the arm and leg to move in the natural planes of movement. Also, the great majority of muscles of the body run in a diagonal and spiral direction, and when they are activated through their full range from the fully stretched position to the fully contracted, the moving part will follow the direction of pull. Rotation of the trunk and pelvis with compensatory rotation in all the joints of the lower limb, or rotation of the trunk in relation to movements of the arm, are seen in all functional activities. Frequent use of rotation causes a torsion strain in all the long bones of the body.

In the exercises devised by Dr Kabat, rotation is considered the key to the movement. Not only is it used to bring a muscle into action by using its rotatory component, as for instance in the re-education of the lower fibres of Pectoralis Major, where the medial rotation is emphasised at the beginning of the movement, followed by adduction; but it is also used to emphasise the action of one muscle within a muscle group: e.g. by rotating the tibia and fibula during knee flexion, either the inner or outer head of Hamstrings can be brought into play, or by inverting the foot during knee flexion, one head of Gastrocnemius can be picked out.

Timing

The sequence of movement in these patterns is called 'timing', the movement starting at the distal end of the limbs, as in the movement of picking up a pail—the fingers grasping, followed by movement at the wrist, elbow, shoulder and trunk. The timing should be smooth and co-ordinated and not made in separate movements. If the correct sequence of movement is used, a strong muscle will reinforce the action of a weak muscle. For instance a strong hand will reinforce the action of the shoulder and a strong foot the action of the knee

Components of Movement

All the muscle groups which combine to bring about these movements are called components of movement and they either flex or extend, abduct or adduct, laterally or medially rotate. In the movement of taking a sweet to the mouth the following components act together: flexion, adduction and lateral rotation of the shoulder, flexion of the elbow, supination, radial flexion of the wrist, and flexion of the fingers to the radial side.

REINFORCEMENT

By using many muscle groups together it will be found that one muscle group will reinforce the action of another. For instance, in the normal subject, if strong resistance is given to dorsiflexion of the foot, the hip will flex, and vice versa, or if resistance is given to extension of the head and neck there will be activity in the upper back extensors. This irradiation or overflow is made use of in the re-education of weak muscles. A pattern of movement is chosen which will include both the weak and strong muscles. Resistance is given to the strong muscles, and it will be found that the contraction of the weak group will be stronger than if it were contracting by itself. As an example, if the abdominal muscles are weak, the exercise will include both flexion of the spine and also resisted flexion of the head and neck, the flexion of the head reinforcing the action of the abdominal muscles.

The method of using this overflow will be described. Having chosen the pattern and taught the patient the movement and being sure that he understands the sequence and commands, all the muscles are put on the full stretch. Resistance is given to all the muscles in the correct sequence, and it will vary according to the strength of the muscles, the weak group having perhaps to be assisted or passively taken to the part of the range in which it contracts. This technique needs skill on the part of the physiotherapist, who may be giving strong resistance with one hand and less with the other. When the strong muscles which have contracted isotonically (concentrically) reach the part of the range in which they contract most strongly in that particular pattern, the contraction becomes isometric (static) against the resistance of the physiotherapist. The movement is now pivoted to the weak group, which will be encouraged to move in as full a range as possible against resistance.

If the resistance to the strong group of muscles is too great, the correct co-ordination of movement is not gained, and it is most important to see that the correct diagonal plane is used. Deviation from this and too strong resistance will cause trick movements which are undesirable.

THE GRIP OF THE PHYSIOTHERAPIST

The principle which should be applied whenever possible is that the resistance should be directional, that is, the hands of the physiotherapist giving the resistance should be placed on the surface of the limb in the direction of the movement. E.g. for giving resistance to Extensor Carpi Radialis Longus and Brevis, the hand of the physiotherapist should be placed on the dorsum of the hand on the radial side. By carefully placing the hands, the movement is facilitated by stimulation of the exteroceptors which are sensitive to touch and pressure. The grip should be firm but never painful.

The arms of the physiotherapist are usually crossed at the beginning of the movement, because in all the patterns there is a rotatory component.

POSITION OF THE PHYSIOTHERAPIST

The physiotherapist should take either a walk or stride-standing position, and the feet should be placed in the same diagonal as the movement. She should use her body weight to give resistance, transferring her weight at the ankles and not using her back.

PATTERNS OF MOVEMENT
FOR THE UPPER AND LOWER EXTREMITIES

There are two diagonal planes of movement for the upper and lower extremities. In one diagonal the limbs move upwards and inwards, and in the opposite direction downwards and outwards. In the other diagonal the limbs move upwards and outwards, and in the opposite direction downwards and inwards. In the Kabat system all movements in an upwards direction towards the head are called flexion, and they may be directed either towards the mid-line or away from the mid-line. The names of the flexor patterns are called flexion-adduction or flexor-abduction, the names being taken from the direction of movement in the shoulder joint.

All movements directed downwards away from the head and backwards are extensor movements, and these also may move either to or away from the mid-line. The names of the extensor patterns are extension-abduction and extension-adduction.

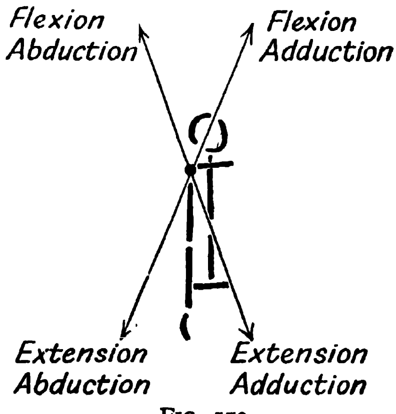


FIG. 179.

Starting Position. All the patterns of movement described are given in the supine position and to the right limbs. Any starting position may be chosen such as *forward lying* or *side lying* or *sitting*, but in these positions the patient must be so placed that full range of movement may take place.

UPPER EXTREMITY

1. FLEXION-ADDUCTION

Starting Position. Extension-abduction.

Direction of Movement. The arm is moved upwards and inwards across the face.

Grip. The left hand of the physiotherapist is placed in the patient's palm. The right hand, which passes under the arm, is placed either on the anterior aspect of the arm over the biceps or the anterior aspect of the forearm.

Sequence of Movement. Flexion and adduction of fingers and thumb, flexion of the wrist, supination, flexion of the elbow, movements of shoulder and lateral rotation of the scapula.

Command: 'Grip my hand, turn and pull up and across.'

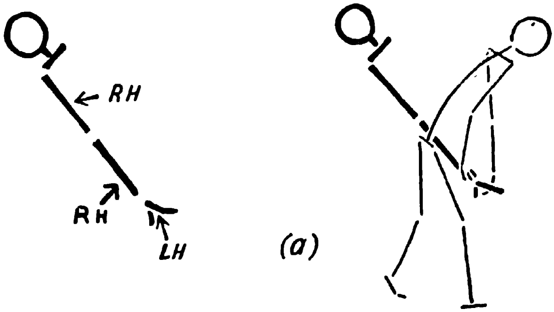
Components of Movement and Muscle Work

Protraction and lateral rotation of the scapula at the sterno- and acromio-clavicular joints.	Serratus Anterior, the upper and lower fibres of Trapezius.
Flexion, adduction and lateral rotation of the gleno-humeral joint.	Clavicular fibres of Pectoralis Major, anterior fibres of Deltoid, Coracobrachialis. Teres Minor and Infraspintus.
Flexion of elbow or extension of elbow may be maintained.	All the flexors of the elbow, the most important being in this pattern: Biceps Brachii and Brachialis.
Supination at the radio-ulnar joints.	Supinator, and Biceps Brachii Brachio-radialis.
Radial flexion at the wrist joint.	Flexor Carpi Radialis
Flexion and adduction of the fingers to the radial side. Flexion and adduction of the thumb.	Flexor Sublimus Digitorum, Flexor Profundus Digitorum, Flexor Longus Pollicis. Adductor Pollicis Transversus and Obliquis, Palmar Interossei and the Lumbricals.

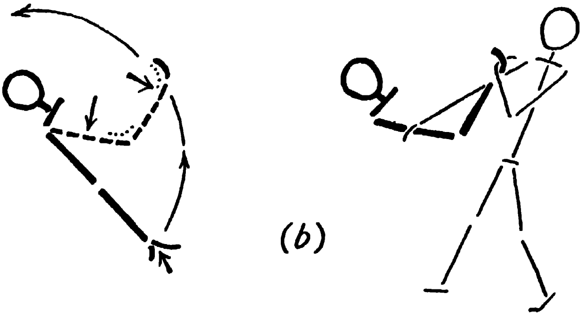
This pattern of movement is specific for re-education of Serratus Anterior, anterior fibres of Deltoid (lateral rotation must be emphasised for this muscle), Biceps, Flexor Carpi Radialis, Adductor and Flexors of the fingers and thumb.

N.B. Only the major muscle groups are described in each pattern of movement.

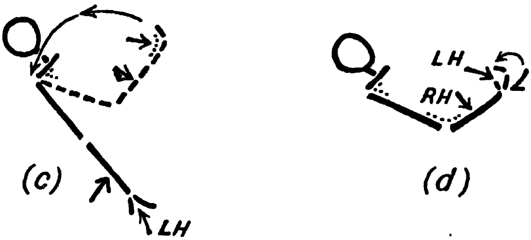
FIG. 180. Flexion Adduction



(*a*) Starting Position



(*b*) Re-education of Shoulder with elbow flexion



(*c*) Re-education of Elbow (*d*) Re-education of Wrist and Fingers

RH = Right Hand. LH = Left Hand. . . . = Isometric Contraction

2. EXTENSION-ABDUCTION

Starting Position. Flexion-adduction, with elbow flexed or extended.

Direction of Movement. The arm is stretched downwards and outwards, similar to the action of putting out an arm to save oneself from falling.

Grip. The right hand of the physiotherapist is placed on the ulnar side of the dorsum of the hand and medial three fingers. The left hand which passes under the arm is placed on the ulnar surface on the extensor aspect of the forearm.

Sequence of Movement. Extension of the fingers and wrist, pronation, extension of the elbow, medial rotation abduction and extension of the shoulder, retraction and depression of the scapula.

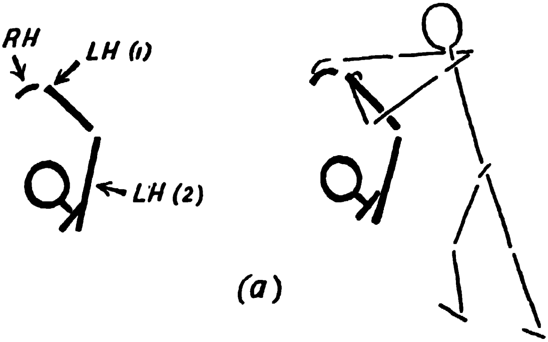
Command: (If the elbow is flexed) 'Stretch up, turn, and push down and out.'

Components of Movement and Muscle Work

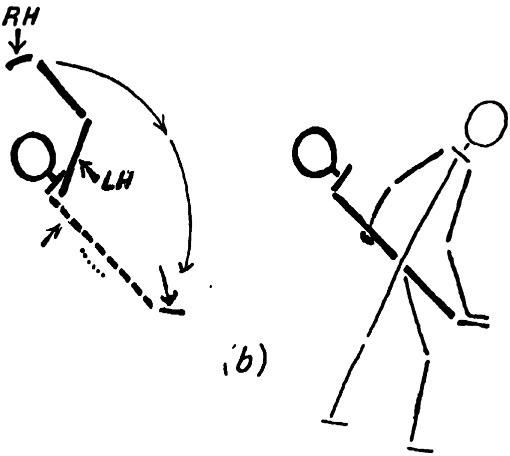
Medial rotation, retraction and depression of the scapula.	Levator Scapulae, Rhomboid Major and Minor, middle and lower fibres of Trapezius, Subclavius.
Medial rotation, extension and abduction of the gleno-humeral joint.	Teres Major, Latissimus Dorsi, Sternocostal Fibres of Pectoralis Major, Posterior Fibres of Deltoid.
Elbow extension.	Triceps Brachii, Anconeus.
Pronation.	Pronator Teres.
Ulnar extension of the wrist.	Extensor Carpi Ulnaris.
Extension and abduction of the fingers to the ulnar side.	Extensor Digitorum, Extensor Minimi Digiti, Abductor Minimi Digiti, Dorsal Interrossei, Lumbricals.
Palmar abduction of the thumb.	Abductor Pollicis Brevis.

This pattern of movement is specific for the Rhomboids, Triceps, Extensor Carpi Ulnaris and Extensors Digitorum, Abductor Pollicis Brevis.

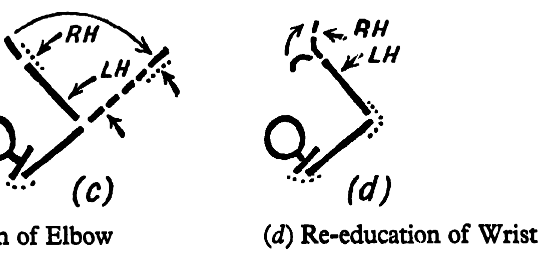
FIG. 181. Extension-Abduction



(*a*) Starting Position



(*b*) Re-education of Shoulder



(*c*) Re-education of Elbow

(*d*) Re-education of Wrist

3. FLEXION-ABDUCTION

Starting Position. Extension-adduction. The elbow may either be extended or flexed.

Direction of Movement. The arm moves upwards and outwards.

Grip. The left hand is placed on the radial side of the dorsum of the hand and the radial three fingers. The right hand which passes under the forearm is placed either on the extensor surface of the arm or forearm.

Sequence of Movement. Extension of the fingers, thumb, and wrist to the radial side, supination, lateral rotation, flexion and abduction of the shoulder and rotation of the scapula.

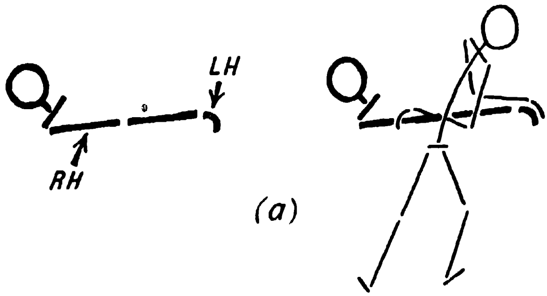
Command: 'Extend the fingers and wrist, turn and lift up and out.'

Components of Movement and Muscle Work

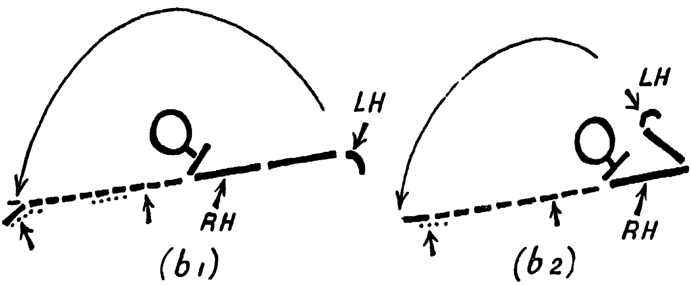
Lateral rotation of the scapula.	Serratus Anterior, upper and lower fibres of Trapezius.
Lateral rotation, flexion and abduction of the gleno-humeral joint.	Teres Minor, Infraspinatus, middle and posterior fibres of Deltoid, Supraspinatus.
If the elbow remains extended.	Triceps (lateral head) Anconeus.
If the elbow flexes.	Biceps (short head), Brachialis, Brachioradialis.
Supination.	Biceps, Supinator, Brachioradialis.
Extension of the wrist to the radial side.	Extensor Carpi Radialis Longus and Brevis.
Extension and abduction of the fingers to the radial side.	Extensors Digitorum, and Indicis, Extensor Minimi Digiti, Dorsal Interrossei, Lumbricals.
Extension and abduction of the thumb.	Extensor Pollicis Longus and Brevis Abductor Pollicis Brevis.

This pattern is specific for the lateral rotators of the scapula, the middle fibres of Deltoid, lateral rotators of the gleno-humeral joint, Extensor Carpi Radialis Longus and Brevis, Extensor Pollicis Longus and Brevis and Abductor Pollicis Longus.

FIG. 182. Flexion-Abduction

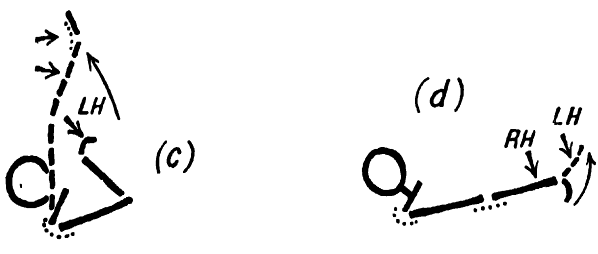


(*a*) Starting Position



1. With Elbow extended 2. With Elbow extension

(*b*) Re-education of Shoulder



(*c*) Re-education of Elbow extension (*d*) Re-education of Wrist and Fingers

4. EXTENSION-ADDUCTION

Starting Position. Flexion-abduction. The elbow may be either extended or flexed.

Direction of Movement. The hand grasps and the arm moves downwards and inwards across the body to the opposite hip.

Grip. The right hand is placed in the patient's palm. The left hand, which passes under the patient's arm, is placed on the flexor surface of either the arm or forearm.

Sequence of Movement. Flexion of the fingers and opposition of the thumb, flexion of wrist, pronation, medial rotation, extension and adduction of the shoulder.

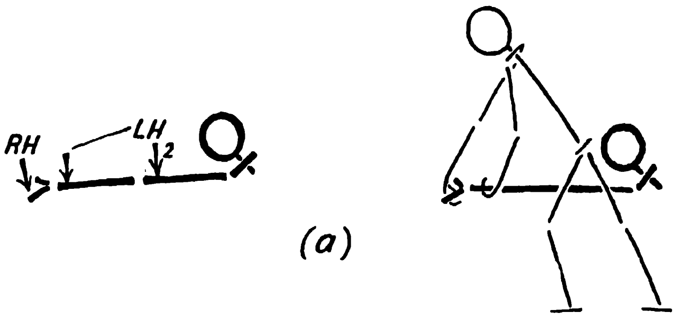
Command: 'Grip, turn and take the arm down and across.'

Components of Movement and Muscle Work

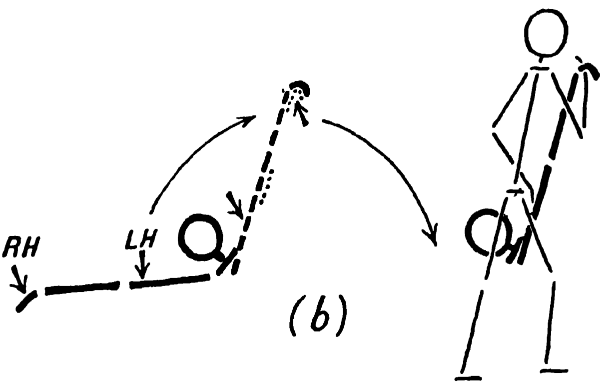
Medial rotation of the scapula and anterior depression.	Middle fibres of Trapezius and the Rhomboids, Levator Scapulae, Pectoralis Minor.
Medial rotation, adduction and extension of the gleno-humeral joint.	Subscapularis, sternal fibres, Pectoralis Major.
Extension of the elbow.	Triceps (emphasis on the medial head) Anconeus.
Pronation.	Pronator Teres, Pronator Quadratus.
Ulnar flexion of the wrist joint.	Flexor Carpi Ulnaris.
Flexion and adduction of the fingers to the ulnar side.	Flexor Sublimus and Profundus. Palmar Interrossei and Lumbricals.
Opposition and flexion of the thumb.	Opponens Pollicis, Flexor Pollicis Longus and Brevis.
Opposition and flexion of the little finger.	Flexor and Opponens Minimi Digiti.

This pattern is specific for Subscapularis, sternal fibres of Pectoralis Major, Triceps, Flexor Carpi Ulnaris, Opponens Pollicis.

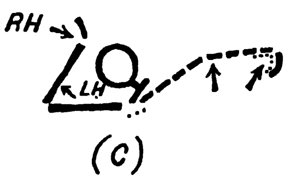
FIG. 183. Extension-Adduction

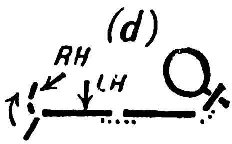


(*a*) Starting Position



(*b*) Re-education of Shoulder with extended elbow





(*c*) Re-education of Elbow (*d*) Re-education of Wrist

LOWER EXTREMITY

I. FLEXION-ADDUCTION

Starting Position. Extension-abduction. The knee may be either extended or flexed.

Direction of Movement. The leg moves upwards and inwards to the opposite shoulder.

Grip. The right hand is placed on the dorsum of the foot on the medial side over the insertion of the Tibialis Anterior. The left hand is placed on the medial aspect of the heel.

Sequence of Movement. Extension of the toes, inversion, flexion or extension of knee, lateral rotation, flexion and adduction of the hip.

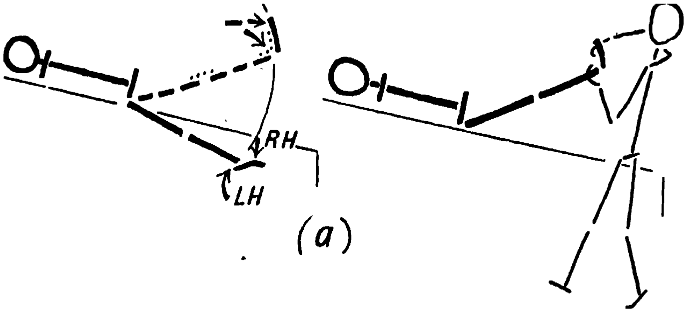
Command: 'Pull up and in.'

Components of Movement and Muscle Work

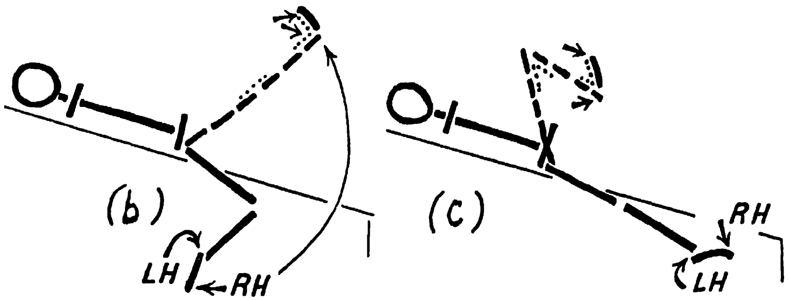
Lateral rotation, flexion and adduction of the hip joint.	Deep lateral rotators, Psoas Major, Iliacus Pectineus, Adductor Magnus, Longus and Brevis.
If the knee is flexed with flexion of the hip joint.	Sartorius.
If the knee remains extended (*a*).	Quadriceps with emphasis on Vastus Medialis.
If the knee is extended from the flexed position (*b*).	Quadriceps with emphasis on Vastus Medialis.
If the knee is flexed from the extended position (*c*).	Hamstrings with emphasis on Semimembranosus and Semitendinosus.
In both (*b*) and (*c*) there is lateral rotation of the tibia on the femur.	
Dorsiflexion and inversion of the foot.	Tibialis Anterior.
Extension and abduction of the toes to the medial side.	Extensor Digitorum Longus. Extensor Hallucis Longus, Extensor Digitorum Brevis, Abductor Hallucis, Dorsal Interossei and Lumbricals.

This pattern is specific for the Ilio-psoas, Adductors, Vastus Medialis, Inner Hamstrings, Tibialis Anterior and Extensor Digitorum and Hallucis.

FIG. 184. Flexion-Adduction



(*a*) Re-education of Hip Flexion with straight leg



(*b*) Re-education of Hip Flexion with knee extension
(*c*) Re-education of Hip Flexion with knee flexion

2. EXTENSION-ABDUCTION

Starting Position. Flexion-adduction. The knee may either remain extended or may flex, or it may start from the flexed position.

Direction of Movement. The leg is thrust downwards and outwards.

Grip. The right hand is placed on the plantar surface on the ball of the foot towards the lateral side. The left hand is placed either on the lateral side of the heel or on the extensor surface of the leg over the insertion of the Hamstrings.

Sequence of Movement. Flexion of the toes and eversion of the foot, flexion or extension of the knee, medial rotation, abduction and extension of the hip.

Command: 'Thrust down and out.'

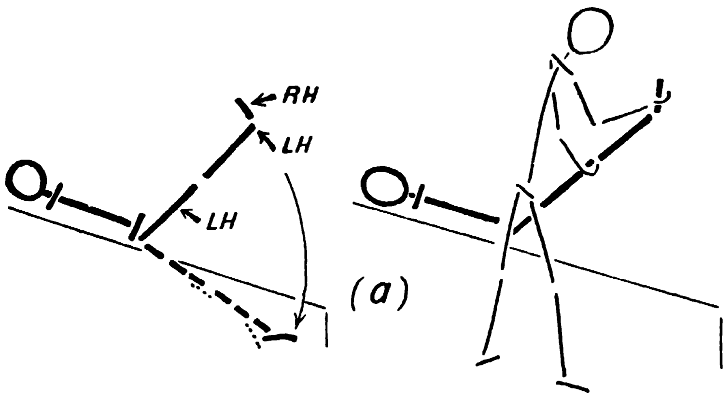
Components of Movement and Muscle Work

Extension, abduction and medial rotation at the hip joint.	Gluteal muscles.

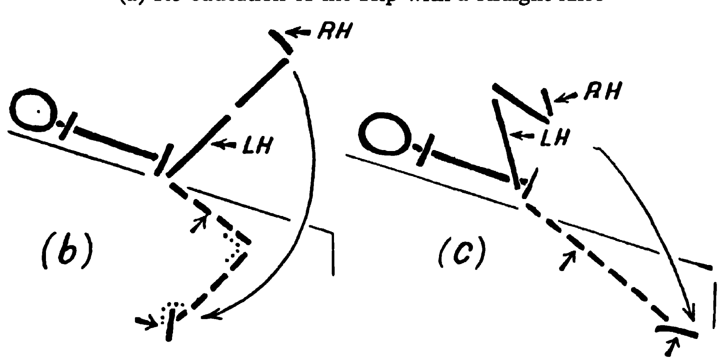
If the knee remains extended (*a*).	Hamstrings with emphasis on Biceps Femoris.
If the knee is flexed from the extended position (*b*).	Hamstrings with emphasis on Biceps Femoris, Popliteus, Gastrocnemius with emphasis on the lateral head.
If the knee is extended from the flexed position (*c*).	Hamstrings with emphasis on Biceps Femoris. Quadriceps with emphasis on Vastus Lateralis and Intermedius.

In the above two patterns there is medial rotation of the tibia on the femur

FIG. 185. Extension-Abduction



(*a*) Re-education of the Hip with a straight knee



(*b*) Re-education of Hip with knee flexion

(*c*) Re-education of Hip with knee extension

The foot plantarflexes and everts.	Peroneus Longus.
The toes flex and adduct to the lateral side.	Flexor Longus Digitorum, small muscles of the foot, Plantar Inter ossei and Lumbricals.

This pattern is specific for Gluteus Medius and Minimus, Biceps Femoris, lateral head of Gastrocnemius, Peroneus Longus. This is the fundamental thrust pattern used in the push-off movement in walking.

3. FLEXION-ABDUCTION

Starting Position. Extension-adduction. The knee may be either extended or flexed.

Direction of Movement. The leg is lifted upwards and outwards away from the opposite ankle.

Grip. The right hand is placed on the dorsum of the foot on the lateral side. The left hand is placed either on the thigh on the antero-lateral aspect or on the lateral side of the heel.

Sequence of Movement. Extension of the toes, eversion, flexion of the knee, medial rotation, abduction and flexion of the hip.

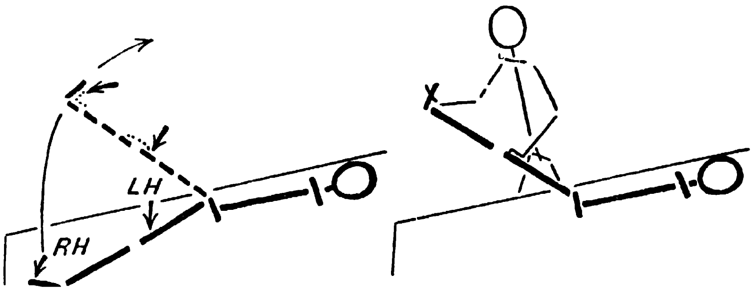
Command: 'Lift the leg up and out.'

Components of Movement and Muscle Work

Flexion, abduction and medial rotation of the hip joint.	Tensor Fascia Lata, anterior fibres of Gluteus Medius.
If the knee remains extended.	Quadriceps with emphasis on Vastus Lateralis and Intermedius, Rectus Femoris.
If the knee is flexed.	Biceps Femoris, Popliteus, lateral head of Gastrocnemius.
In this movement there is medial rotation of the tibia on the femur.	
Dorsiflexion and eversion of the foot.	Extensor Digitorum Longus, Peroneus Brevis and Tertius.
Extension and abduction of the toe to the lateral side.	Extensor Digitorum Brevis, Dorsal Interossei and Lumbricals.

This pattern is mostly used to stretch contractures of the Adductor muscles. Also for re-education of the Peroneus Brevis and Extensor Digitorum Longus.

FIG. 186. Flexion-Abduction



Re-education of Hip with knee extended

4. EXTENSION-ADDUCTION

Starting Position. Flexion-abduction. The knee may remain extended or may extend from the flexed position, or may flex from the extended position.

Direction of Movement. The leg moves downwards and inwards towards the opposite foot.

Grip. The right hand is placed on the plantar surface of the foot on the medial side. The left hand which passes under the leg is placed on the medial aspect of the heel, or it may be placed on the extensor surface of the thigh, the arm passing under the thigh from the lateral aspect.

Sequence of Movement. Flexion of the toes, inversion and plantar-flexion of the foot, flexion or extension of the knee, lateral rotation, extension and adduction of the hip.

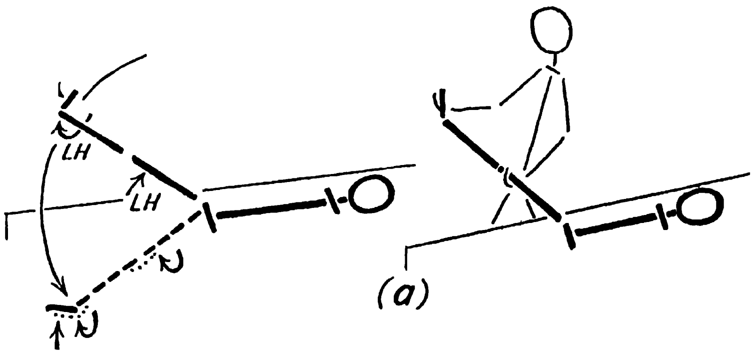
Command: 'Push down and in.'

Components of Movement and Muscle Work

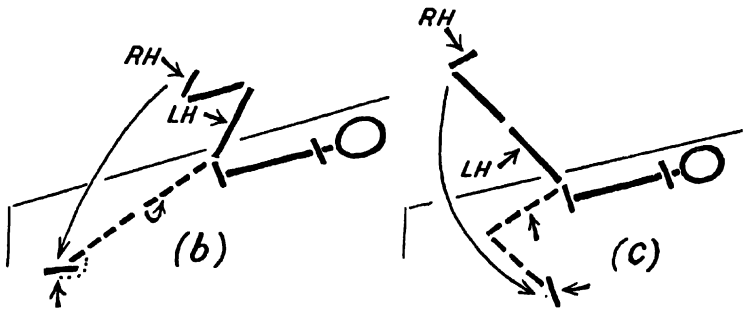
Extension, adduction and lateral rotation of the hip joint.	Gluteus Maximus, deep lateral rotators, Adductor Magnus.
If the knee remains extended (*a*).	Quadriceps with emphasis on Vastus Medialis.
If the knee extends from the flexed position (*b*).	Quadriceps with emphasis on Vastus Medialis.

If the knee flexes from the extended position (*c*).	Semimembranosus, Semitendinosus. Gastrocnemus with emphasis on the medial head.
In the above two patterns the tibia laterally rotates on the femur.	
Plantarflexion, inversion of the foot.	Gastrocnemius, Soleus, Tibialis Posterior.
Flexion of the toes and adduction towards the medial side.	Flexor Longus Digitorium, Flexor Hallucis Longus, small muscles of the foot, Plantar Interossei and Lumbricals.

FIG. 187. Extension-Adduction



(*a*) Re-education of Hip Extension with knee extended



(*b*) Re-education of Quadriceps with hip extension

(*c*) Re-education of Knee Flexors with hip extension

This pattern is specific for Adductor Magnus, inner Hamstrings when the knee is flexed, Tibialis Posterior and the long flexors of the toes. When this pattern is performed with a flexed knee, there is lengthening of the Tensor Fascia Lata and the Ilio-tibial band.

HEAD AND NECK PATTERNS OF MOVEMENT

The head and neck also move in a diagonal plane. There are two patterns: flexion and extension, and in both of these there is a rotary component of movement.

Flexion of the Head and Neck (to the right)

Starting Position. Head and neck extension to the left. With the patient in the supine position the head is extended over the end of the plinth and turned to look over the left shoulder.

Direction of Movement. The head is raised to look downwards and to the right.

Grip. The physiotherapist stands behind the patient in a walk standing position in line with the direction of movement. The right hand is placed under the chin and over the right mandible. The left hand under the occiput.

Sequence of Movement. The chin is pulled down, the head is rotated and flexed.

Command: 'Pull the chin in, rotate and pull the head up and across.'

Components of Movement and Muscle Work

Flexion in the Atlanto-occipital joint.	Rectus Capitis Anterior, Longus Capitis, Sternomastoid on the side towards the movement. Suprahyoid muscles.
Rotation at the Atlanto-axial joint.	Inferior oblique, Sternomastoid of the opposite side to the movement.
Flexion and rotation of the cervical spine.	Longus Cervicus, Scaleni on the side of the movement. Infrahyoid muscles.

Extension of the Head and Neck (to the left)

Starting Position. Head and neck flexion to the right. The head looks downwards and across towards the right hip.

Direction of Movement. The head is raised and pressed backwards to look over the opposite shoulder.

Grip. The physiotherapist stands behind the patient in walk standing position in line with the direction of movement. The right hand is placed over the chin and the right mandible, the left under the occiput.

Sequence of Movement. The chin is raised, the head rotated and extended.

Command: 'Raise the chin. Rotate and press the head back to look over the left shoulder.'

Components of Movement and Muscle Work

Extension in the Atlanto-occipital joint.	Rectus Capitis Posterior Major and Minor, Superior Oblique.
Rotation of the left in the Atlanto-axial joint.	Inferior Oblique
Extension and rotation of the cervical spine to the left.	L. Splenius Capitis, L. Longissimus Capitis, R. Semispinalis, R. upper fibres of Trapezius, and R. Sternomastoid. Prolongations of the Sacrospinalis in the cervical spine.

TRUNK PATTERNS

The patterns of movement for the Trunk are either flexion or extension combined with rotation and side flexion. The flexion patterns are divided into upper and lower Trunk Flexion and the extension into upper and lower extension patterns of movement. The movements take place in a diagonal plane, from a line drawn from the shoulder to the opposite hip. Any deviation from this line will give excess side flexion and this is an unwanted movement.

Upper Trunk Flexion (to the right)

Starting Position. Upper trunk extension to the left. From the *lying, long sitting* or *sitting* position the patient's trunk is extended and rotated to the left, the head looking over the left shoulder.

Direction of Movement. The head and trunk are flexed and rotated towards the opposite hip.

Grip. The right hand is placed on the forehead over the right eyebrow, the left in front of the left shoulder diagonally, in line with the direction of the movement.

Sequence of Movement. Flexion of the chin, rotation of the head, flexion and rotation of the cervical, thoracic and lumbar spines. The head is held in the flexed and rotated position whilst the movement is pivoted to the trunk.

Command: 'Turn the head, pull up and across' (if in the supine position).

Components of Movement and Muscle Work

Flexion in the Atlanto-occipital joint.	Rectus Capitis Anterior, Longus Capitis, Sternomastoid on the side towards the movement. Suprahyoid muscles.
Rotation at the Atlanto-axial joint.	Inferior Oblique, Sternomastoid of the opposite side to the movement.
Flexion and rotation of the cervical spine.	Longus Cervicis, Scaleni on the side of the movement. Infrahyoid muscles.
Flexion and rotation of the dorsal and lumbar vertebrae. .	Left external obdominal oblique, right internal abdominal oblique, Rectus Abdominis, Transversus Abdominis, left external intercostals, right internal intercostals.

This pattern is specific for the trunk rotators to the right.

Upper Trunk Extension (to the left)

Starting Position. Upper trunk flexion to the right. The most suitable positions for this exercise are *prone lying*, *side lying* or *sitting* on a stool. The head and trunk are flexed and rotated to the right with the head looking towards the opposite hip.

Direction of Movement. The head and trunk are extended and rotated to the left, the head looking over the left shoulder.

Grip. In the *prone* and *side lying* positions the right hand is placed on the back of the head, the left on the back of the patient's shoulder diagonally and in line with the movement. In the *sitting* position the movement may include the flexion-abduction pattern for the left arm in which case the physiotherapist's left hand is placed on the dorsum of the patient's left hand and her right on the back of the head.

Sequence of Movement. The chin is raised, the head is rotated and extended, followed by rotation and extension of the thoracic and lumbar spine.

Command: 'Push up and back and look over the left shoulder.'

Components of Movement and Muscle Work

Extension in the Atlanto-occipital joint.	Rectus Capitis Posterior Major and Minor, Superior Oblique.
Rotation to the left in the Atlanto-axial joint.	Inferior Oblique.
Extension and rotation of the cervical spine to the left.	L. Splenius Capitis, L. Longissimus Capitis, R. Semispinalis, R. Upper fibres of Trapezius, R. Sternomastoid, Prolongation of the Sacrospinalis in the cervical spine.
Extension and rotation of the dorsal and lumbar vertebrae to the left.	R. Serratus Posterio-Superior, L. Serratus Posterior Inferior, L. Sacrospinalis, R. Multifius, R. Rotatores.

This exercise is specific for the trunk rotators to the left, with emphasis on the muscles attached to the spine and to the retractors of the scapulae.

Lower Trunk Flexion (to the right)

Starting Position. Lower trunk extension to the left. The patient lies in the supine position with the legs extended down and to the left side as far as possible. The knees may remain extended or may be flexed.

Direction of Movement. Both extremities are lifted up and over to the right.

Grip. If the legs remain extended, the physiotherapist stands at the end of the plinth facing the patient. The right hand is placed on the lateral side of the right heel, the left on the medial side of the left heel. If the knees are flexed during the exercise, the right hand is placed over the dorsum of both feet and the left over the anterior aspect of both femurs.

Sequence of Movement. The feet dorsiflex, the right everting and the left inverting. The hips flex and rotate, the right abducting and medially rotating, the left adducting and laterally rotating. The pelvis rotates and the trunk side flexes and rotates.

Command: 'Pull up and over.'

Components of Movement and Muscle Work

The right leg follows flexion-abduction pattern. The left leg follows the flexion-adduction pattern.	These patterns have already been described.
The pelvis is tilted upwards to the right.	Trunk side flexors on the right side, the emphasis being laid on the vertical fibres of the abdominal muscles.

This pattern is specific for the trunk side flexors and for the internal abdominal oblique on the side of the movement.

Lower Trunk Extension (to the left)

Starting Position. Lower trunk flexion to the right. The patient lies in the supine position with both legs flexed and as far as possible to the right. The knees are extended and may remain extended or may be flexed during the exercise.

Direction of Movement. Both extremities move over and downwards to the left.

Grip. The physiotherapist stands on the left side of the patient in a stride standing position in line with the direction of the movement. The left hand is placed under the heels, the right under the thighs.

Sequence of Movement. The feet are plantarflexed, the left being everted and the right inverted; the hips are extended and rotated, the left being medially rotated and the right laterally rotated. The pelvis is tilted and rotated.

Command: 'Push down and over to the opposite side.'

Components of Movement and Muscle Work

The right leg follows the extension adduction pattern.	These patterns have already been described.

The left leg follows the extension abduction pattern of movement.	
The pelvis is tilted to the left.	Trunk side flexors to the left, the emphasis being laid on the trunk side flexors of the back. The left Sacrospinalis, L. Quadratus Lumborum.

The pattern of movement is specific for the trunk side flexors of the back on the side towards the movement.

PROPRIOCEPTIVE FACILITATION

For a perfectly co-ordinated movement the motor centres of the Central Nervous System must receive accurate information through the proprioceptive pathways, recording the tensions in the muscles by means of the muscle spindle, and the position of the body in space by means of the labyrinth. If there is interruption of the afferent pathways as seen in Disseminated Sclerosis or Tabes Dorsalis, the movements become clumsy, inco-ordinated and useless. By increasing the afferent stimulation there is an increased excitation of the motor cells, and by constant repetition of this stimulation, functional pathways may be laid down within the Central Nervous System which compensate for the loss of the original pathways caused by disease.

In order to gain a maximal response in a muscle there must be a maximal excitation of the Anterior Horn Cells. This excitation is gained through stimulation of the proprioceptors by stretching a muscle and giving it resistance, and from the impulses from the upper motor centres. By the summation of these factors there will be a maximal discharge from the Anterior Horn Cells (Fulton, 1911).

Stimulation of the Proprioceptors

The proprioceptors are stimulated by:—

(*i*) *Stretching the Muscles.* All muscles to be activated are first fully stretched, not only with regard to all the components of the movement to be performed but also across all joints over which they pass, e.g. the Biceps Brachii is fully stretched when the arm is abducted to forty-five degrees, extended and medially rotated, the elbow being extended and the forearm pronated. By using mass movement patterns all the muscles concerned in the movement are fully stretched before they contract. This stretching increases the proprioceptive stimulation and results in a bombardment of the Anterior Horn Cells by excitatory impulses. The stretch should not be prolonged and in the case of very weak muscles it should be quick.

(*ii*) *Maximal Resistance to Muscular Contraction.* Maximal resistance is given to all the components of movement in a mass movement pattern. The resistance will vary according to the strength of the muscles but it must never be strong enough to arrest the movement, which should be slow and smooth. Resistance, whether it is given manually or by means of a pulley and weight circuit, stretches the muscle spindles and increases proprioception. This method of increasing proprioception is more effective than stretching for the purpose of gaining facilitation of movement.

The exteroceptors, which are sensitive to touch and pressure, are stimulated by the pressure of the physiotherapist's hands when, in giving resistance, these are placed on the surface of the limb which is in the direction of the movement (see page 211).

TECHNIQUES OF PROPRIOCEPTIVE FACILITATION

All techniques are superimposed upon the patterns of movement which have already been described.

a. *Straight Resistance*

After fully stretching all the muscles concerned, maximum resistance is applied to all components of the movement pattern. The movement is done slowly and through the entire range of the pattern.

b. *Repeated Contractions*

This is a useful technique for building up muscle power and endurance and for increasing joint range. It is only used when the muscle is capable of a fair contraction. After fully stretching the muscle in all its components and asking the patient to move in the required direction, resistance is given to the movement as far as the strongest part of the range, i.e. where the muscle is able to contract most strongly. The patient is then asked to 'hold' against resistance, the contraction now being isometric. During this period of 'holding' the physiotherapist gradually tries to increase the resistance, and when a 'build up' is felt the patient is asked to move again, while the physiotherapist momentarily eases up the resistance to allow the movement to take place but still gives maximal resistance to the movement. This technique is repeated throughout as full a range as possible.

c. *Reversals*

This is a facilitatory technique which is based on 'Successive Induction' (Fulton, 1911). Frequently in sport activity, when power is needed the prime movers are fully stretched by the contraction of the antagonists, e.g. in weight-throwing. This technique is used when power is called for, also to gain relaxation in a group of muscles and for the re-education of co-ordination of movement. There are two methods of applying this technique:—

(*i*) *Slow Reversals.*

As the name implies, the exercise will include two movements in the opposite direction. For instance, flexion-adduction of the leg is immediately followed by extension-abduction, with no relaxation between the movements. This last point is important, for if relaxation is allowed at the change of direction, all the excitatory impulses which have been summated at the Anterior Horn Cells will be dissipated and there will be no build-up of power.

(*ii*) *Slow Reversal-Hold-Relax.*

This method is used for reducing spasm and for increasing joint range. The limb is moved to the point at which it is unable to move further owing to spasm and pain. The following sequence now takes place. The patient is asked to contract the tight muscles isometrically against resistance, the resistance being carefully graded. When the maximal contraction has been gained without pain, the patient is asked to relax. This is immediately followed by an isotonic contraction of the muscles antagonistic to the muscles in spasm. It is most important to see that the patient relaxes and that the movements are slow and smooth. The sequence is repeated. The contraction of the tight muscles must always be isometric, and in this way range is gained. Both active relaxation and reciprocal relaxation are utilised in this technique.

REFLEX ACTIVITY

Reflex activity is another means of facilitation. Balance reactions (Holmes, 1917) which are responsible for maintaining or regaining equilibrium are activated by pushing the patient off balance. A mass reflex movement is brought into play, thereby bringing into action a weak muscle, which is a component of this movement. The harder the push the greater will be the response of the muscles which save the patient from falling.

It is essential that the correct position is taught and the patient able to maintain it, before this technique is applied. At first the pushes may be gentle and slow, the command being 'do not let me move you to the right' or 'do not let me move you to the left' or 'do not let me turn you'. The hands of the physiotherapist are carefully placed in the direction of movement. When the patient is able to control these movements, the pushes may become quicker and from an unknown direction. The result is a pure reflex action, the movement automatically bringing the patient back into the central position.

The positions chosen for this type of exercise depend on the ability of the patient to maintain them. They may be given in the *lying*, *prone kneeling*, upright kneeling (*kneeling*), asymmetrical kneeling (*half kneeling*), heel sitting (*sit kneeling*), *sitting*, *standing* and *half standing* positions. Not only do these movements re-educate the balance reactions, but they also re-educate the postural reflex.

CONCLUSION

In this method, movement is re-educated in patterns based on functional activities. It emphasises the important part the proprioceptors play in the control of normal movement.

A complete description of this method of re-education of movement, including all the techniques and patterns, evaluation of the patient's performance and treatment programmes, will be found in *Proprioceptive Neuromuscular Facilitation*, written by Miss Margaret Knott and Miss Dorothy E. Voss.

PART V

13

NEUROMUSCULAR CO-ORDINATION

CO-ORDINATED MOVEMENT

CO-ORDINATED movement, which is smooth, accurate and purposeful, is brought about by the integrated action of many muscles, superimposed upon a basis of efficient postural activity. The muscles concerned are grouped together as prime movers, antagonists, synergists and fixators, according to the particular function they are called upon to perform.

GROUP ACTION OF MUSCLES

The contraction of the prime movers results in the movement of a joint, while the reciprocal relaxation of the opposing group, the antagonists, controls their action without impeding it. Other muscles may work as synergists, either to alter the direction of the pull of the prime movers, or, where the latter pass across more than one joint, to stabilise the joint in which movement is not required. Efficiency is still further ensured by muscular fixation of the bone, or bones, from which the prime movers take origin (or alternatively, into which they are inserted, should they work with reversed origin and insertion). These fixator muscles may be in the immediate vicinity of the movement, but when strong resistance is offered, muscles all over the body are frequently involved.

NERVOUS CONTROL

The Motor Pathways. The action of each muscle group is determined by the afferent impulses which reach it by the motor pathways.

The Cerebral Cortex. Voluntary movement is usually, if not invariably, initiated in response to some sensory stimulus. It is now thought that an initiation centre exists in the brain stem which alerts the cerebral cortex, which then is responsible for planning the pattern of movement. This plan is based on memories of patterns used on previous occasions.

The Cerebellum. The cerebellum is a receiving station of information which reaches it by the afferent pathways conveying impulses of kinaesthetic sensation from the periphery and from other parts of the brain including the cerebral cortex and the vestibular nucleus. In the light of this information the delicate adjustments, which ensure harmonious inter-action of the various groups of muscles concerned in the pattern of movement, are made and conveyed to the anterior horn cells by either the extra-pyramidal tracts or other descending pathways of the spinal cord.

Kinaesthetic Sensation. The afferent impulses of kinaesthetic sensation arise from proprioceptors situated in muscles, tendons and joints and they record contraction or stretching of muscle and the knowledge of movement and position of the limbs. Some of these impulses reach the level of consciousness but many end in the spinal cord and cerebellum.

INCO-ORDINATION

Interference with the function of any one of the factors which contribute to the production of a co-ordinated movement will result in jerky, arhythmic or inaccurate movement, which is said to be inco-ordinated, as the harmonious working together of the muscles is disturbed. The type of inco-ordination, and the exercises designed to help in overcoming it, vary according to the location of the lesion which causes it. Four main types usually benefit from suitable exercise therapy.

Causation

1. Inco-ordination associated with weakness or flaccidity of a particular muscle group.

In this case, either some lesion of the lower motor neurones prevents the appropriate impulses from reaching the muscles, or the condition of the muscles modifies their normal reaction to these impulses.

2. Inco-ordination associated with spasticity of the muscles.

Lesions affecting the motor area of the cerebral cortex, or the upper motor neurones, result in spasticity of the muscles, therefore, even when some appropriate impulses are able to reach them, the condition of the muscles is such that their response to them is abnormal.

3. Inco-ordination resulting from cerebellar lesions.

This is generally known as cerebellar 'ataxia', the prefix 'a' meaning 'without' and the Greek word 'taxis' meaning 'order'. There is marked hypotonicity of the muscles, which tire easily, and inadequate fixator action, not only of the muscles directly concerned with the group action, but of the body generally. Movement is irregular and swaying, with a marked intention tremor.

4. Inco-ordination resulting from loss of kinaesthetic sensation.

'Sensory ataxia', or in the case of tabes dorsalis, 'tabetic ataxia', describes this type. Without using his eyes to gain the information, the patient with this condition is completely unaware of the position of the body in space, or of the position of the joints. The muscles are hypotonic and tire easily, but they are unaware of this as the sensation of fatigue is not recorded.

Involuntary movements, sometimes associated with these conditions, or a state of abnormal general tension superimposed on an otherwise normal pattern of group action, may interfere with movement and reduce its efficiency.

RE-EDUCATION

Co-ordinated movement is natural to the body, which tends to remain still if only inco-ordinated movement is possible. It is therefore of major importance to interest and encourage patients suffering from inco-ordination to persevere in making the effort to overcome it. This requires infinite patience and persistence on the part of the physiotherapist, especially if and when the condition is associated with mental deterioration. Each patient requires individual attention as the problems of no two are identical, but as progress is made, group work is a valuable adjunct to individual treatment.

The Use of Alternative Nervous Pathways

It is rare that all the available nervous pathways, by which the impulses essential for co-ordinated movement travel, are blocked, and the purpose of re-education is to encourage the use of those which remain, or to develop alternative routes.

As an analogy it may be helpful to consider a pathway worn through an acre or so of bracken or some other type of undergrowth. It is easy enough to walk through it when the pathway is used constantly and is well worn. If, however, the pathway is blocked, an alternative route can be used, but the going will be difficult at first though it will become progressively easier each time it is used, provided the same alternative route is used on each occasion. In this way a new pathway is eventually established.

The Condition of the Muscles

As a preliminary to re-educating the movement, the condition of the muscles requires attention as they are the effector organs concerned. They must be prepared to receive the co-ordinating impulses so that their reaction to them is as normal as possible, by an attempt to relax those which are spastic or tense, and to strengthen those which are weak. It is probable also that in all long-standing cases in which inco-ordination is a feature, some degree of disuse atrophy is present owing to the disinclination to move.

PRINCIPLES OF RE-EDUCATION

Weakness or Flaccidity of a Particular Muscle Group. This differs from the other conditions in that the inevitable inco-ordination which results is usually only transitory. Inco-ordinated movement is not tolerated by the body if it can be avoided, and in this case it is able to avoid it by altering the pattern of the movement in such a way that the function of the affected muscles is transferred to other groups. This substitution of an alternative pattern is the basis of 'trick' movement, which is often functionally effective, but always wasteful of energy.

The aim of treatment is to restore the power of the muscles and to rehabilitate them. The power of the muscles is developed by specific exercises designed for this purpose (see Chapter 9, 'Muscle Power') and their rehabilitation is ensured by preserving the memory of the natural pattern of movement in which they are involved. The latter is achieved by frequent passive movements, if the muscles are paralysed, or by active assisted exercise until such time as they are sufficiently powerful to take their full share in the co-ordinated effort required to perform the movement freely. Failure to preserve the memory of the natural and efficient pattern of movement results in permanent substitution of the 'trick' movement, in which case the rehabilitation of the muscles to full function is never completed. 'Trick' movements are wasteful of energy and may lead to mechanical strain elsewhere; they are extremely difficult to eradicate and should therefore only be allowed to become established when there is no hope of recovery of muscle power.

Spasticity of Muscles. The spasticity of the muscles modifies their reaction to the stimuli they receive as they cannot, or can only with difficulty, relax and so allow movement to occur. There is marked reluctance to attempt movement, while in those which are achieved, the essential rhythm which is characteristic of efficient movement is lost. Treatment is designed to promote relaxation, to stimulate effort, to give confidence in the ability to move and to train rhythm. Relaxation methods have already been described (see Chapter 5, 'Relaxation'). Active exercises based on everyday movements help to make the patient as independent as possible and give him confidence. Those which involve the use of the more proximal joints and are large and basic in character are used first. All exercises are performed rhythmically to aid relaxation and reduce fatigue, assistance being given when necessary but only after, and as long as, the effort is made to do them independently. Rhythmic counting, music, or the rhythm of a bouncing ball are used to regulate the speed of the movement, as the effort to keep in time helps to interest the patient and demands his full attention. Training in accuracy and the finer and highly co-ordinated movements, such as those of the hand, is deferred until basic movements and rhythm are established.

Cerebellar Ataxia. Loss of the function of the cerebellum, which is a co-ordinating centre, results in loss of the co-ordinating impulses which are normally discharged from it. The muscles become hypotonic and postural fixation is disturbed, consequently balance is difficult and movements are irregular, swaying and inaccurate.

Any improvement which results from treatment by exercises is probably due to an increased use of the pathways which remain, or it is thought possible that the cerebrum may be able to compensate to some extent for the loss of cerebellar function.

The aim of the exercises is to re-educate balance, rhythm and precision of movement. The patient must be helped according to his needs, to move about and perform utilitarian movements, especially those which involve balance, such as sitting down, standing up and walking. Exercises, similar to those designed on Frenkel's principles for use in the treatment of sensory ataxia, may be used to train precision and smoothness of movement, but in cases in which there is loss of cerebellar function any attempt by the patient to control the movement by watching it is useless.

Loss of the Kinaesthetic Sense. Information as to the whereabouts of the body in space, the position of the joints and the tension in muscles, forms an essential part of the data upon which neuromuscular co-ordination is based. Lesions causing loss of this information result in hypotonicity of the muscles and inco-ordinated movement Substitution of the sense of sight to compensate for the loss of the kinaesthetic sense forms the basis of re-education, and by maintaining relatively normal body movements it may be possible to bring into use some undamaged but hitherto redundant nervous pathways capable of conveying the impulses of kinaesthetic sensation.

Exercises based on Frenkel's principles are used to train smooth movement and precision, with emphasis on the ultimate aim of helping the patient to carry out the normal activities of everyday life.

Frenkel's Exercises

Dr H. S. Frenkel was Medical Superintendent of the Sanatorium 'Freihof' in Switzerland towards the end of the last century. He made a special study of tabes dorsalis and devised a method of treating the ataxia, which is a prominent symptom of the disease, by means of systematic and graduated exercises. Since then his methods have been used to treat the inco-ordination which results from many other diseases, e.g. disseminated sclerosis.

He aimed at establishing voluntary control of movement by the use of any part of the sensory mechanism which remained intact, notably sight, sound and touch, to compensate for the loss of kinaesthetic sensation. The process of learning this alternative method of control is similar to that required to learn any new exercise, the essentials being—

a. Concentration of the attention.
b. Precision.
c. Repetition.

The ultimate aim is to establish control of movement so that the patient is able and confident in his ability to carry out those activities which are essential for independence in everyday life.

Technique

1. The patient is positioned and suitably clothed so that he can see the limbs throughout the exercise.

2. A concise explanation and demonstration of the exercise is given before movement is attempted, to give the patient a clear mental picture of it.

3. The patient must give his full attention to the performance of the exercise to make the movement smooth and accurate.

4. The speed of movement is dictated by the physiotherapist by means of rhythmic counting, movement of her hand, or the use of suitable music.

5. The range of movement is indicated by marking the spot on which the foot or hand is to be placed.

6. The exercise must be repeated many times until it is perfect and easy. It is then discarded and a more difficult one is substituted.

7. As these exercises are very tiring at first, frequent rest periods must be allowed. The patient retains little or no ability to recognise fatigue, but it is usually indicated by a deterioration in the quality of the movement, or by a rise in the pulse rate.

Progression

Progression is made by altering the speed, range and complexity of the exercise. Fairly quick movements require less control than slow ones. Later, alteration in the speed of consecutive movements, and interruptions which involve stopping and starting to command, are introduced. Wide range and primitive movements, in which large joints are used, gradually give way to those involving the use of small joints, limited range and a more frequent alteration of direction. Finally simple movements are built up into sequences to form specific actions which require the use and control of a number of joints and more than one limb, e.g. walking.

According to the degree of disability, re-education exercises start in *lying* with the head propped up and with the limbs fully supported and progress is made to exercises in *sitting*, and then in *standing*.

Examples of Frenkel's Exercises

Exercise for the legs in *lying*.

a. *lying (Head raised); Hip abduction and adduction.*

The leg is fully supported throughout on the smooth surface of a plinth or on a re-education board.

b. *lying (Head raised); one Hip and Knee flexion and extension.*

The heel is supported throughout and slides on the plinth to a position indicated by the physiotherapist.

c. *lying (Head raised); one Leg raising to place Heel on specified mark.*

The mark may be made on the plinth, on the patient's other foot or shin, or the heel may be placed in the palm of the physiotherapist's hand.

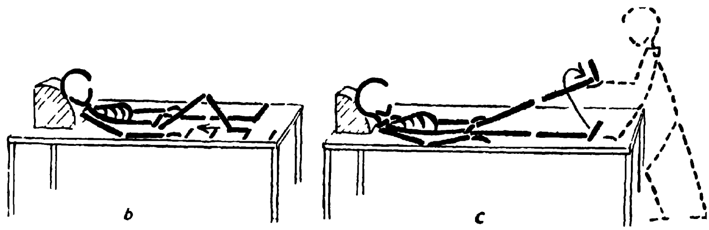


FIG. 188

d. *lying (Head raised); Hip and Knee flexion and extension, abduction and adduction.*

The legs may work alternately or in opposition to each other. Stopping and starting during the course of the movement may be introduced to increase the control required to perform any of these exercises.

Exercise for the legs in *sitting*.

e. *sitting; one Leg stretching, to slide Heel to a position indicated by a mark on the floor.*

f. *sitting; alternate Leg stretching and lifting to place Heel or Toe on specified mark.*

g. *stride sitting; change to standing and then sit down again.*

The feet are drawn back and the trunk inclined forwards from the hips to get the centre of gravity over the base. The patient then extends the legs and draws himself up with the help of his hands grasping the wall-bars or other suitable apparatus.

Exercise for the legs in *standing*.

h. *stride standing; transference of weight from Foot to Foot.*

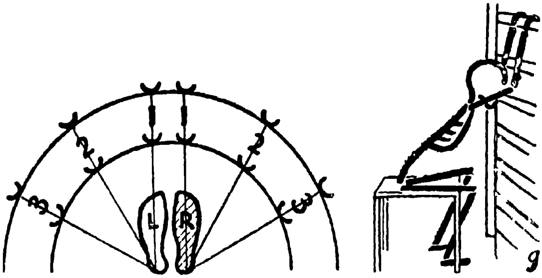


FIG. 189. *e*, Plan to show suitable marking on floor

i. *stride standing; walking sideways placing Feet on marks on the floor.*

Some support may be necessary, but the patient must be able to see his feet.

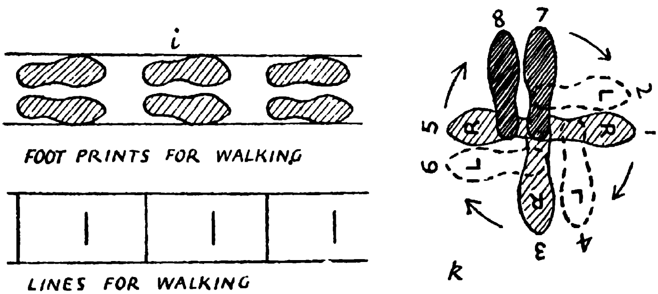


FIG. 190

j. *standing; walking placing Feet on marks.*

The length of the stride can be varied by the physiotherapist according to the patient's capacity.

k. *standing; turn round.*

Patients find this difficult and are helped by marks on the floor.

l. *standing; walking and changing direction to avoid obstacles.*

Group work is of great value as control improves, as it teaches the patient to concentrate on his own efforts without being distracted by those of other people. In walking, he gains confidence and becomes accustomed to moving about with others, to altering direction and stopping if he wishes, to avoid bumping into them. The ability to climb stairs and to step on and off a kerb helps him to independence.

Exercises for the arms.

m. *sitting (one Arm supported on a table or in slings); Shoulder flexion or extension to place Hand on a specified mark.*

n. *sitting; one Arm stretching, to thread it through a small hoop or ring.*

o. *sitting; picking up objects and putting them down on specified marks.*

Diversional activities such as plaiting, building with toy bricks, or drawing on a blackboard, lead to more useful movements such as using a knife and fork, doing up buttons and doing the hair.

Exercises to Promote Movement and Rhythm

All exercises are repeated continuously to a rhythmic count, or to suitable music.

a. *sitting; one Hip flexion and adduction (to cross one Thigh over the other), the movement is then reversed and repeated.*

b. *half lying; one Leg abduction to bring Knee to side of plinth, followed by one Knee bending to put Foot on floor, the movement is then reversed and repeated.*

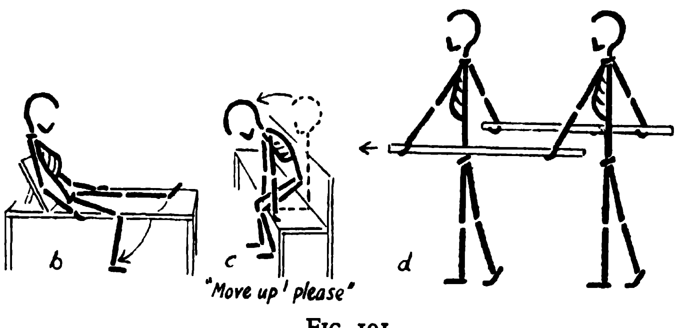


Fig. 191

c. *sitting; lean forward and take weight on Feet (as if to stand), then sit down again.* Later this can be done progressing along the seat as if moving up to make room for someone else to sit.

d. *standing; Arm swing forwards and backwards (with partner, holding two sticks).*

e. *standing or walking; bounce and catch, or throw and catch a ball.*

Marching to music, ballroom dancing or swimming, if possible, should be encouraged.

14

POSTURE

POSTURE is the attitude assumed by the body either with support during muscular inactivity, or by means of the co-ordinated action of many muscles working to maintain stability or to form an essential basis which is being adapted constantly to the movement which is superimposed upon it.

INACTIVE POSTURES

These are attitudes adopted for resting or sleeping, and they are most suitable for this purpose when all the essential muscular activity required to maintain life is reduced to a minimum. Those postures which make minimal demands upon the muscles responsible for the maintenance of essential body functions, such as respiration and circulation, are preferable. The postures or positions used for training general relaxation fulfil these conditions by allowing freedom for respiratory movement and the least possible work for the heart muscle.

ACTIVE POSTURES

The integrated action of many muscles is required to maintain active postures, which may be either static or dynamic.

Static Postures. A constant pattern of posture is maintained by the inter-action of groups of muscles which work more or less statically to stabilise the joints, and in opposition to gravity or other forces. In the erect postures they preserve a state of equilibrium.

Dynamic Postures. This type of active posture is required to form an efficient basis for movement. The pattern of the posture is constantly modified and adjusted to meet the changing circumstances which arise as the result of movement.

THE POSTURAL MECHANISM

The Muscles

The intensity and distribution of the muscle work which is required for both static and dynamic postures varies considerably with the pattern of the posture, and the physical characteristics of the individual who assumes it. The groups of muscles most frequently employed are those which are used to maintain the erect position of the body, by working to counteract the effects of gravity. They are consequently known as the anti-gravity muscles and their action with regard to joints is usually that of extension.

These anti-gravity muscles present certain structural characteristics which enable them to perform their function with efficiency and the minimum of effort. The form of the muscles is multi-pennate and fan-shaped, an arrangement which signifies powerful action as opposed to the ability to produce a wide range of movement at high speed. Many of the constituent fibres are 'red', indicating their capability of sustained contraction without fatigue, due to their low metabolic rate of action (Chapter 9, p. 113).

Nervous Control

Postures are maintained or adapted as a result of neuromuscular co-ordination, the appropriate muscles being innervated by means of a very complex reflex mechanism.

The Postural Reflex. A reflex is, by definition, an efferent response to an afferent stimulus. The efferent response in this instance is a motor one, the anti-gravity muscles being the principal effector organs. Afferent stimuli arise from a variety of sources all over the body, the

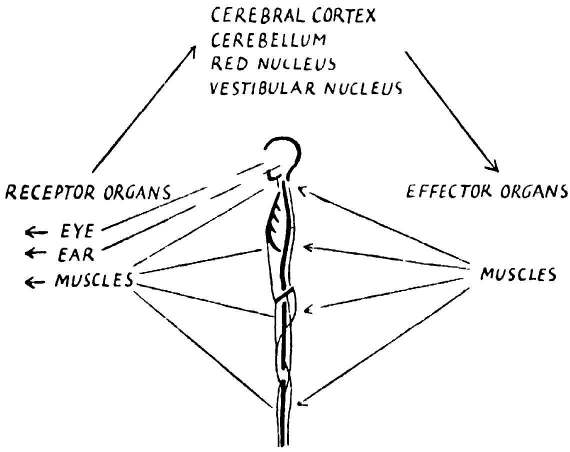


FIG. 192

most important receptors being situated in the muscles themselves, the eyes and the ears.

(i) *The Muscles.* Neuromuscular and neurotendinous spindles within the muscles record changing tension. Increased tension causes stimulation and results in a reflex contraction of the muscle, and so appears to be a manifestation of the myotatic, or stretch, reflex.

(ii) *The Eyes.* Visual sensation records any alteration in the position of the body with regard to its surroundings, and the eyes form one of the receptors for the 'righting' reflexes which enable the head and body to restore themselves to the erect position from other less usual attitudes.

(*iii*) *The Ears.* Stimulation of the receptors of the vestibular nerve results from the movement of fluid contained in the semicircular canals of the internal ear. Each canal lies in a different plane, which is at right angles to both the others, and any movement of the head disturbs the fluid they contain, and thus knowledge of the movement and the direction in which it takes place are recorded.

Skin sensation may also play a part, especially that of the soles of the feet, when the body is in standing positions.

Impulses from all these receptors are conveyed and co-ordinated in the Central Nervous System, the chief centres involved being the cerebral cortex, the cerebellum, the red nucleus and the vestibular nucleus.

A very elementary summary of the chief components of the complex series of reflexes which together constitute the Postural Reflex is given in the diagram opposite. Details will be found in any Physiology textbook.

The Pattern of Posture

Patterns of posture, both static and dynamic, are gradually built up by the integration of the many reflexes which together make up the Postural Reflex. Some of these component reflexes are inborn and some are conditioned, being developed as the result of constant repetition of postures maintained by voluntary control.

Good Posture

Posture is said to be good when it fulfils the purpose for which it is used with maximum efficiency and minimum effort.

As the physical characteristics of no two people are identical, the precise pattern of good posture must vary with the individual. It is possible, however, to generalise to some extent. For example, in the erect postures the alignment of specific parts of the body usually leads to perfect balance of one segment upon another, a state which can be maintained with the minimum of muscular effort and which is aesthetically pleasing to the eye.

As dynamic postures involve constant readjustment to maintain the efficiency of the postural background throughout the progress of the movement, they are much more difficult to assess. In many activities, however, the same alignment of the various segments of the body which is satisfactory in the erect static postures forms the basis from which these adjustments are made; for example, in walking or sitting and writing. In the erect positions the plane of this alignment is vertical, but in many dynamic postures it is inclined or even horizontal, in which case the effect of gravity on the various body segments is altered and the muscle work required to maintain the alignment is adjusted accordingly.

Development of Good Posture

Efficient posture develops quite naturally, provided the essential mechanisms for its maintenance and adjustment are intact and healthy.

The chief factors which predispose to the health and development of the muscles and the postural reflex are—

(*i*) a stable psychological background,
(*ii*) good hygienic conditions,
(*iii*) opportunity for plenty of natural free movement.

Emotion and mental attitude have a profound effect upon the nervous system as a whole, and this is reflected in the posture of the individual. Joy, happiness and confidence are stimulating and are reflected by an alert posture in which positions of extension predominate. Conversely unhappiness, conflict and a feeling of inferiority have just the opposite effect and result in postures in which positions of flexion are most conspicuous.

This connection between mental and physical attitudes has always been recognised and used in dancing and on the stage. It is certain that the mental attitude affects the physical, either temporarily or permanently. Is it not possible that this can also happen in reverse? In other words, cannot a physical attitude adopted consciously affect the mental attitude?

Good hygienic conditions, particularly with regard to nutrition and sleep, are essential for a healthy nervous system and for the growth and development of bones and muscles. In addition, the opportunity for plenty of natural free movements also encourages the harmonious development of the skeletal muscles. Activities which are much enjoyed by the normal healthy child at play, for example, running, jumping, and climbing, are those in which movements of active extension predominate.

Poor Posture

Posture is poor when it is inefficient, that is, when it fails to serve the purpose for which it was designed, or if an unnecessary amount of muscular effort is used to maintain it.

Faulty alignment of the body segments in the erect positions may lead to the necessity for additional muscle work to maintain balance. On the other hand, efficient compensation may take place, in which case no additional muscular effort is required, but the attendant ligamentous strain or cramping of thoracic movement are disadvantages which cannot be ignored. In addition, postures which involve a marked increase in any or all the curves of the spine are aesthetically displeasing, clothes do not fit these subjects well and this may in itself have an unwelcome psychological reaction.

The purpose of dynamic posture is to serve as an efficient and adaptable background to movement. Posture patterns which do not fulfil this function impede and reduce the efficiency of the movement

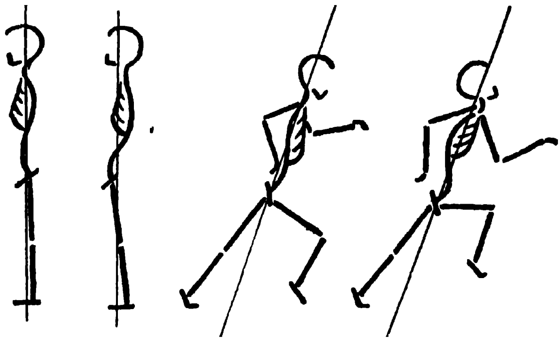


FIG. 193. Good and Faulty Alignment in *standing* and *running*

and therefore must be considered poor, e.g. standing square to the net while making a forehand drive at tennis.

Tension in muscles other than those required to act either to produce movement or to maintain posture hinders the efficiency of both and wastes energy.

Factors which predispose to Poor Posture

The causes of poor posture are often very obscure, and, even if they are known, are difficult to remove.

The factors which most often contribute to the establishment of an inefficient postural pattern are the mental attitude of the patient and poor hygienic conditions. General debility after a constitutional illness and prolonged fatigue are also contributory causes, as they reduce the efficiency of the nervous system as a whole.

Local factors such as localised pain, muscular weakness, occupational stresses, or localised tension which serves no useful purpose, lead to muscular disbalance and alter the postural pattern, but do not necessarily reduce its efficiency under the circumstances. If, however, this altered pattern of posture is continued after the cause for it is removed, it must be regarded as a postural defect.

A faulty idea of what constitutes good posture may also lead to the establishment of an inefficient pattern by repeated voluntary effort.

PRINCIPLES OF RE-EDUCATION

The measures which can be taken by the physiotherapist to combat poor posture and to train another and more efficient postural pattern depend largely on the cause. The success of any physical treatment invariably depends on her ability to gain the co-operation of the patient.

Postures which are the result of an unsatisfactory mental attitude and poor hygienic conditions can only be remedied permanently by an alteration in the habitual mental attitude and by improvement of the hygienic conditions, and these are measures with which the physiotherapist herself is not often able, or competent, to deal. Postural defects rarely lead to marked structural changes; if they are prolonged, however, muscles and ligaments do adapt their length to the habitual position maintained by the joints, and this may lead to some limitation of the normal joint range. This limitation, if present, may make it impossible for the patient to assume a good position at some future date when the attitude and conditions have improved. Relaxation, mobility exercises and a repeated presentation of a satisfactory postural pattern will prepare the way for improvement. During this period of instruction a cheerful atmosphere, a spirit of enjoyment and judicious praise may build up the desire of the patient to re-establish a more satisfactory postural pattern by voluntary effort.

When general debility and fatigue are the cause, these must obviously be treated first. Training in relaxation to avoid unnecessary tension and assistance in remembering the feeling of a satisfactory alignment of the body are helpful meanwhile.

Local conditions which result in the alteration of postural pattern, and which can be removed, should receive suitable attention. Pain is alleviated by appropriate means, muscular weakness cured by specific exercise to restore the balance of muscle power, localised tension removed by relaxation methods. Occupational strains can sometimes be relieved by analysis of the movements required and substitution of a new pattern which is more satisfactory mechanically. While these local methods of treatment are in progress, a good pattern of posture must be constantly presented to the patient, so that it is remembered and will therefore be re-established when the local cause of alteration has been removed.

A faulty idea of correct posture can be cured by inducing the patient to accept a new and satisfactory pattern and then by teaching him how to assume it and make it habitual by repeated voluntary effort.

Technique of Re-education

The atmosphere in which instruction is given to the patient is of the greatest importance in postural re-education, and the physiotherapist can do much to gain co-operation by her manner and approach. The patient must be made to feel that the acquisition of good posture is worth while, and that any efforts he makes to attain it will be noticed and appreciated, while his difficulties and shortcomings will be understood. Individual instruction is essential as no two patients have identical difficulties, but they have also much in common to learn and, for this, group instruction is valuable. The inclusion of group activities in any programme of re-education is conducive to an atmosphere of enjoyment and the patient is usually stimulated by working with others.

Relaxation

The ability to relax is an important factor in re-education, as some degree of useless and unnecessary tension is nearly always associated with poor posture. To begin with, general relaxation with the body in horizontal positions reduces muscular tension and gives a feeling of alignment. Voluntary relaxation of specific muscle groups can then be taught and practised so that the patient learns to recognise tension and is able to relax at will, if and when it develops during the maintenance of either static or dynamic postures.

Because of the excessive use of the arms in front of the body and the necessity to lean forwards which many occupations demand, as in washing clothes or writing at a desk, these tensions usually occur in muscles round the shoulder girdle and in the neck extensors. Local and voluntary relaxation of these groups can be taught in *lying* and the erect positions, first by the contrast method and later by learning to recognise a state of tension and then 'letting go'.

Examples of Relaxation Methods

a. *crook lying, lying or prone lying; general relaxation.*
b. *crook lying; relax Shoulders to supporting surface, with expiration.*
c. *Forehead support prone lying; Head raising and lowering with relaxation.*
d. *sitting; Shoulder shrugging and retraction followed by relaxation.*

Mobility

The maintenance of normal mobility is essential to enable a wide variety of postures to be assumed. Abnormal mobility, however, is a liability rather than an asset, as additional muscular effort is required to control it, and in some cases it may be a contributory factor in the development of poor posture.

Normal mobility is maintained by general free exercises which are rhythmical in character and include full-range movement of all joints. Emphasis is laid on full extension as this is the movement which is most liable to limitation, except in the case of the lumbar spine and the shoulder joints, where flexion and lateral rotation respectively are more likely to be limited. If joint stiffness has developed, specific mobility measures for the joint affected are used to make sure that the loss of range in one joint is not masked by a compensatory increase in the mobility of the adjacent joints. For example, stiff shoulders which will not permit full elevation of the arm are readily compensated by hyperextension in the lumbar spine.

Exercises and agilities which increase the respiratory excursions are of great importance and should on no account be omitted, and those which involve hanging positions give good alignment of the body and are much enjoyed by children.

Muscle Power

General muscular weakness is rarely it ever the root cause of poor posture, but the opportunity for free movement and harmonious muscular development helps to maintain their tone and efficiency, and so to withstand any strain which may be imposed by occupational stresses. The use of the anti-gravity muscles is of special importance as these are the groups which are most frequently called upon to act in a postural capacity.

If and when joint stiffness is present, exercise for the muscles which have been stretched are essential to ensure relaxation of their antagonists and to restore muscular balance. For example, work for the upper Back Extensors and Scapula Retractors is required during re-education of a stooping posture (see Chapter 9, 'Muscle Power', p. 147).

Presentation of a Good Posture

There is no one method of teaching any one patient to assume and experience the feeling of good posture. The method and the technique selected for a particular patient must depend on the patient and the physiotherapist, but one thing appears to be essential and that is that the physiotherapist must have faith in the method she adopts.

Those who have habitual poor posture often feel uncomfortable and unnatural in any position other than the one to which they have become accustomed. This is not surprising, but emphasises the importance of convincing the patient that good posture 'looks' right, and will prove efficient in the long run. In other words, the physiotherapist must 'sell' the pattern of good posture.

A mirror, posture recorder or photographs may be useful for this purpose, so that the image can be compared with pictures of experts which demonstrate a good general pattern of alignment. This is particularly impressive in training dynamic posture in activities such as tennis, diving and lifting where faulty posture can have such a marked effect on the efficiency of the movement.

Training of static postures in the erect position is basic, partly because most people, with the exception of very small children, are compelled to spend most of their waking hours in upright positions which are relatively static, for example, standing and sitting. Even in walking the alignment of the trunk remains more or less the same, and incidentally the ability to remain still without undue effort, when the occasion demands it, is a habit well worth acquiring.

In the erect postures, the control of each segment of the body in relation to the rest is by no means a simple thing to learn. The position of the whole is profoundly influenced by the position of the head, of the pelvic tilt, and by the state of comfort and position of the feet. Different authorities stress the importance of one or other of these factors but in fact they are all important and any one may prove to be the dominant factor.

The Head

An upward thrust of the vertex in the erect positions may be sufficient to achieve satisfactory alignment of the whole body, provided no unnecessary tension is allowed to develop elsewhere. To prevent

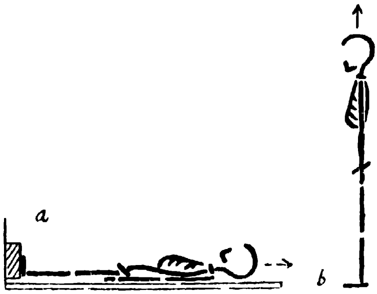


FIG. 194

tension in the initial stages this thrust may be practised in the horizontal and inclined positions, e.g.

a. *crook lying or lying with Feet support; Body lengthening*
b. *half lying, sitting or standing; Head stretching upwards.*

The Pelvic Tilt

Voluntary control of the pelvic tilt teaches the patient to recognise any deviation from the normal, and trains him to be able to adjust and correct it at will. In *crook lying* the trunk is supported in a position of alignment and the pelvis is free to move in an antero-posterior direction, therefore this position is selected to start with. Contraction of the Hip Extensors, as if to lift the hips off the floor, and of the straight Abdominal Muscles, tilts the pelvis backwards and the reverse movement is achieved by the hollowing of the lumbar spine.

Once the ability to adjust the pelvic tilt has been learnt it can be performed in a variety of positions which include *sitting* and *standing*, and it can be controlled at the angle of tilt required.

c. *crook lying; Gluteal and Abdominal contraction* (to flatten lower Back to floor), *followed by relaxation, then hollowing of Back.*
d. *low wing sitting; Pelvis tilting and adjustment.*

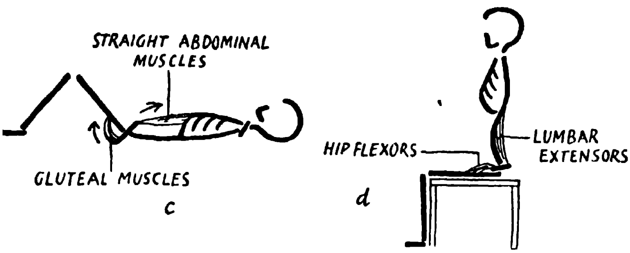


FIG. 195

e. *low wing standing; Pelvis tilting and adjustment.*
The movement may be felt and appreciated by the control position of the hands.

The Feet

Painless, mobile and strong feet form a stable base on which the weight of the body is balanced and supported. The arches are braced, and the weight of the body adjusted so that it falls through the summit of the arch and is distributed evenly to the areas of the feet which are designed for weight-bearing. In walking, the weight is transferred progressively from one part of the weight-bearing area to the next. Bracing of the arches can be practised with or without weight-bearing, but in every case the weight-bearing areas must be in contact with the floor or other supporting surface, otherwise the sensory stimulation of pressure on the soles of the feet is lost and the surfaces are unlikely to remain on the same plane.

f. *sitting; bracing of the longitudinal arch and pressing the Toes to the floor.* (All weight-bearing areas must be kept in contact with the floor.)
g. *standing (Feet turned forwards and slightly apart); Hip rotation outwards* (to make patellae look laterally).

The Complete Picture

Where the complete pattern of good posture does not emerge as the result of the adjustment of any one of the areas which have been already mentioned, it must be built up gradually and progressively from complete relaxation. A state of balanced tension and much concentration is required at first, but the effort and tension are progressively reduced by repetition. Every new poise or movement requires, effort at first, but this is reduced as the pattern on which it is based is simplified and becomes more efficient and the passage of the co-ordinating impulses on the neuromuscular pathways is facilitated. Provided there is sufficient repetition and precision, the new and satisfactory pattern of posture becomes habitual and therefore no longer requires voluntary control, as it is maintained by a conditional reflex which is part of the postural reflex.

PART VI

15

INDIVIDUAL, GROUP AND MASS TREATMENT BY EXERCISES

THE physiotherapist must obviously give her undivided attention to a patient when passive movement is given, but active exercise can often be taught or supervised either individually or with others.

INDIVIDUAL EXERCISE

A careful assessment of a patient's ability to perform active exercise is made before suitable exercises can be selected. Once the exercises are selected, individual and precise instruction is required to ensure accuracy of movement with adequate correction and assistance, if and when it is necessary. In addition, it is essential that the purpose of the exercises should be explained briefly and simply so that the patient understands how his efforts can be directed towards his final rehabilitation.

In many cases individual treatment must be continued, as for instance when—

(*i*) the patient is very ill or weak and requires much assistance,
(*ii*) precision of movement is of prime importance,
(*iii*) the nature of the disability is unique,
(*iv*) manual resistance is given, or
(*v*) the attention of the patient is too easily distracted by the presence of others.

Too much individual attention during recovery can reduce the speed and hinder the progress of rehabilitation, as some patients tend to consider the presence of the physiotherapist essential for the performance of exercise, whereas in fact they are quite capable of carrying it out on their own initiative. At this stage, group treatment is a valuable adjunct to individual treatment and can later replace it.

GROUP EXERCISE

Group exercise is the logical progression from individual treatment, as by this arrangement the patient receives a measure of individual attention and at the same time learns to take some responsibility for his own efforts while working with others. At the outset it is essential to distinguish Group Exercise from Mass Exercise. The latter is performed by a large number of people to a formal word of command, or a rhythm dictated by an instructor, and little or no assistance or correction can be given to the individual. In contrast, where a small number of people work together in Group Exercise there is concentration on the needs of the individual while the stimulation which results from working with others is utilised.

A small number of patients, preferably never exceeding six or eight, are grouped together because they have some common disability which will benefit from exercises which are similar in character. While there is common ground with regard to the exercises there is also room for modification in range, effort and speed of movement, so that they can be adapted to suit the individual needs of each member of the group and thus produce the maximum effect. Because of the common ground, the pattern of each exercise can be taught to the whole group simultaneously; time is then allowed for free practice of the whole or part of the exercise, during which each patient performs the movement according to his own capacity and in his own rhythm, being helped, encouraged and corrected by the physiotherapist according to his individual need.

The Value of Group Exercise

1. The patient learns to take a measure of responsibility for his own exercise, and so is helped towards adequate home practice. Patients treated individually for too long come to rely on the presence and assistance of the physiotherapist and are conditioned to feel that these are essential. In a group, the amount of attention given to the individual patient decreases in proportion to the number in the group, and yet a measure of help, supervision and encouragement is available when required.

2. The patient learns to work with others and no longer considers himself set apart from his fellow-men because of his disability. Help is at hand if he needs it, meanwhile he learns to take his place with other members of the community.

3. The patient is given confidence in the treatment and is therefore stimulated to further effort, as progress on the part of other members of the group does not pass unnoticed.

4. The patient is given confidence in his ability to hold his own with others when the group performs some exercises in unison.

5. Effort is stimulated by some activities which call for a mild form of competition. True competition can only take place on equal ground, therefore activities of this kind must be carefully controlled by the physiotherapist.

6. Patients are helped to forget their disability temporarily by

Objective and Game-like Activities, which are only possible in Group Treatment. This helps to promote natural movement, general activity and a cheerful outlook. In small groups careful supervision can be given and help is at hand if required.

The value of Group Exercise must always be assessed from the point of view of the benefit to the patient. From the physiotherapist's point of view much of her time is saved when several patients are treated simultaneously, but her effort must be very concentrated if maximum value from the treatment is to be obtained by all the patients in the group.

The Disadvantages of Group Treatment

These arise from the abuse or misunderstanding of the system. Faulty selection of patients, inadequate explanation to the patient, lack of, or inefficient, grading of groups, overcrowding of groups, and poor technique of instruction on the part of the physiotherapist, are the most common causes of failure to benefit the patient.

The Organisation of Group Exercise

As with any other form of exercise therapy the keynote of success is to give the patient the right exercises, at the right time, and in the right way. In other words, to match the exercises he is required to perform to his capacity to perform them.

Selection of Patients. Any patient who is capable of, and is expected to do, home exercise can be drafted into a suitable group once the basic instruction has been given and is understood. Individual attention may also be required in many cases and is obviously essential when there is no suitable group. Group treatment cannot replace individual treatment; it is a progression from and an adjunct to it.

Grading of Groups. The patient must only be drafted to a group in which the exercises performed are suitable to his capacity, and he must be progressed from that group to another as his capacity increases.

Groups are formed according to the location and nature of the disability, the age group and sex of the patients, and are graded according to the nature and strength of the exercises performed.

For example, a convenient method of grading Leg Exercises for Men is as follows—

(*i*) *Leg C.* (Traumatic Injuries; for non-weight-bearing exercise.)

(*ii*) *Leg B.* (Traumatic Injuries; for partial weight-bearing exercise.)

(*iii*) *Leg A.* (Traumatic Injuries; for full weight-bearing exercises and activities leading to final rehabilitation.)

The members of these groups are most likely to be fairly young men who could expect to achieve full rehabilitation, e.g. before and after menisectomy.

(*iv*) *Leg X.* (Non-traumatic Conditions, for non-weight-bearing exercise.)

The majority of members of this group would in all probability be elderly men who would require exercise at a slower rhythm, and from whom relatively little progress can be expected, e.g. osteo-arthritis.

(*v*) *Walking.* In this group several patients suffering from a variety of lesions are supervised at practice; some who have a thorough understanding of their difficulties and how to overcome them will need little attention, others may need much help.

This list of groups is by no means exhaustive and is only intended as an example of a satisfactory arrangement for a large department in which a wide variety of conditions are treated. It is an advantage for progressive groups to exercise simultaneously, as this facilitates the movement of patients from one group to another without the necessity of altering the time of the appointment for the treatment. Re-grading must be made at frequent intervals. It can either be done by the doctor or by the physiotherapist; it is a skilled job and its efficiency determines the success of this method of giving treatment.

Explanation to the Patient. Before joining a group the patient must be given preliminary instruction in some of the exercises and an explanation of their purpose with regard to his disability. His confidence must be gained so that he feels he can report progress or any further symptoms which may arise. It is sometimes advisable to let a patient watch a group at work, or to allow him to take part in some of the exercises with the help of the physiotherapist with whom he has had individual treatment, before he is finally expected to work as a member of the group.

The Number of Patients in a Group. The number of patients who can be successfully treated in a group depends to some extent on the nature of their disability and how much help each will require, and also on the ability of the physiotherapist to see and give this help when it is needed. Overcrowding results in a form of mass exercise as the number of patients in the group makes it impossible for the physiotherapist to give adequate individual attention. The ability to look after several patients at one and the same time only comes with experience.

The Technique of Instruction. The technique of conducting Group Exercises is basically the same as that required to teach and supervise individual exercise. The ability to see where help and encouragement are required in the case of several people is merely an extension of the ability required to give it to one, and it comes with practice and experience.

Some have a natural flair for this type of work and their personality gets across without much attention to technique; still, every skill has its technique, a knowledge of which will improve performance, and even without much natural ability, a very adequate standard can be reached by studying this technique and by experience in applying it.

Mass Exercise

This method is only suitable for giving general exercise. Because of the large number who take part, it is impossible for the instructor to give much more than general encouragement and correction during the presentation of the exercises. Frequently, but not necessarily, the exercises are done in unison to a formal command or a rhythm dictated by the instructor, in which case the identity of the individual is submerged to produce a uniform pattern of movement, as for example in army drill or exercises arranged for demonstration purposes.

Introduced at the right time and used in conjunction with individual or group treatment this method of giving exercise often plays a part in the whole scheme of rehabilitation, as the circulation and general exercise tolerance are improved, and the discipline of working with others is stimulating. For many cases, however, it is unsuitable as it does not cater for the specialised needs of the individual.

16

TABLES AND SCHEMES

An exercise table is a list of exercises designed for the use of a patient or group of patients at a particular stage of treatment to fulfil certain specific aims.

A scheme of treatment is a plan which indicates the sequence of treatment over a period of time. When a scheme of treatment includes exercises, a series of tables is required to anticipate or keep pace with the changing condition of the patient and to maintain interest. Each of these tables is a progression on, or modification of, the previous one.

A table of exercises may be either general or specific in character according to the nature of the condition from which the patient for whom it is designed is suffering, and the aims of treatment.

A. General Tables

These provide activity for the whole body, although they can be adapted to lay emphasis on exercise for a particular area if this is required. They are used in the treatment of general conditions, e.g. debility, rheumatoid arthritis, or as an adjunct to treatment given for a specific area whenever the nature of a localised lesion tends to reduce the normal efficiency of body movement generally.

The order in which the exercises are arranged within a general table is usually based on a definite plan which, however, need not be followed too rigidly, as any arrangement made must of necessity be extremely flexible to allow it to be adapted to the needs and condition of each patient.

Exercises which are easy and involve no great muscular effort come first to warm and prepare the body for the peak of effort which comes rather more than half-way through the table when the large muscles of the trunk work to move the heaviest parts of the body. The table is completed by the inclusion of exercises which require no great muscular effort but considerable control and concentration.

By this arrangement plenty of variety of exercise is possible, as each part of the body is moved in turn and fatigue is prevented by ensuring that no one group of muscles is used in the same way in consecutive exercises.

Basic Plan for a General Table of Exercises

1. *Respiratory Exercise.* This may be either a specific Breathing Exercise or some simple activity during which the patient gets out of breath with consequent increase in the respiratory excursions.

2. *Extremity Exercises.* These are easy and often well-known exercises to prepare the body for more strenuous activity. Either the Arm or Leg Exercise can come first according to which is most suitable to follow the Respiratory Exercise, or they may be combined.

3. *Head and Neck Exercise.* These are generally used to improve the posture of the head and are often more conveniently placed between the Trunk Exercises, as they provide relatively easy work in comparison with that required during movements which involve the trunk, and so prevent fatigue.

4. *Trunk Exercises.* Back and Abdominal Exercises, Trunk Side Bending and Rotation are all included in this group. They may be performed in any order which is convenient within the group.

5. *Extremity Exercises.* The Arm and Leg Exercises included at this stage of the table differ from those at the beginning of the table in that they require more control and concentration, possibly because of the difficulty of the starting position or of keeping the body in a state of equilibrium. A Balance Exercise is usually included in all tables designed for patients with poor posture or gait.

6. *Respiratory Exercise.* This is designed to have a quietening effect and is frequently followed or accompanied by correction of posture in the common positions and activities of everyday life, e.g. sitting, standing and walking.

Posture is checked or corrected before, during and after every exercise to ensure a satisfactory basis on which the movements made during the exercises are superimposed. When rest periods between exercises are necessary or desirable, these may take the form of relaxation in a suitable posture, e.g. *crook lying, crook half lying* or *Back lean standing,* or a change provided by a 'break' may be all that is required. A 'break' is some form of easy activity in which there is usually an element of competition and which is much enjoyed.

Change of Tables

Exercise tables are changed at suitable intervals, the period of time for which each one is used varying with the speed at which the condition of the patient changes, the frequency of the treatments and the capacity of the patient to learn the exercises. Too frequent changes often reduce the benefit to be gained by accurate knowledge and ample practice of the exercises. Changes which are too infrequent result in the exercises becoming unsuitable for the present condition of the patient and so impede progress and lead to boredom.

B. Specific Tables

These are used in the treatment of local conditions when exercise for a specific area of the body is required, e.g. Colles fracture. When the local condition is such that it impedes the normal activities of the body as a whole, and when time permits, both specific and general tables may be included in a treatment.

The arrangement of the exercises within a specific table can only be planned in broad outline, those which are strengthening and mobilising in effect being placed at the beginning, and those which train co-ordination and the functional use of the part predominating towards the end of the table. An effort must be made to avoid using the same muscles strongly in consecutive exercises to avoid undue fatigue.

A satisfactory plan of the type of exercise and the timing of a half-hour period of treatment by group exercises is as follows:—

(*i*)	Assemble group, take register and assess condition of individual members of the group	5 mins.
(*ii*)	Subjective exercises which are strengthening or mobilising in effect during which the patient concentrates on precision of movement	10 „
(*iii*)	Objective exercises and activities by means of which the functional use of the area being treated is tested and developed	10 „
(*iv*)	Suggestion and practice of exercises suitable for home practice	5 „

Table Making

Before drawing up a table of exercises, the physiotherapist must know certain relevant facts about the patient or group of patients for whom it is to be designed.

From the doctor or the doctor's notes the following information about each patient is acquired:—

1. Name
2. Age
3. Sex
4. Occupation
5. History
6. Present condition
7. Diagnosis
8. Treatment ordered, including Physical Treatment
9. Date of review by doctor.

From her own examination of the patient she observes and assesses:—

10. The patient's capacity for exercise and his attitude to treatment
11. The number of treatment periods to be arranged each week. This may have been decided by the doctor
12. The duration of each treatment period.

With this knowledge the physiotherapist is in a position to specify the precise aims of treatment and to select exercises suitable to fulfil these aims. When the table is completed, a careful check must be made to see that the aims of treatment have been fulfilled, that the effort required is well balanced and that the continuity and variety of the exercises is satisfactory. A record of the exercise table, dated and written in correct terminology, is kept for use at subsequent treatments and for reference, together with notes indicating the patient's reaction and progress.

Schemes of Treatment

A scheme of physical treatment for a patient is usually outlined by the doctor who prescribes it, and it may include several types of physical treatment such as massage, electrotherapy and occupational therapy in addition to passive movement and active exercise. The exercise treatment is represented by a series of tables, each one of which is suited to fulfil the immediate aims of treatment at a particular time.

Example. In treating a fracture at least three tables would be required, the first for use while the limb was in plaster, the second immediately the plaster was removed, and the third during the final stage of rehabilitation before discharge.

17

INSTRUCTING THE PATIENT

THE instruction which is given to a patient with regard to exercises must be presented to him in a manner which will gain his co-operation and ensure that he has a thorough understanding of what is required of him.

THE CO-OPERATION OF THE PATIENT

A brief explanation of the purpose of the exercises, given in simple terms which can be understood, goes a long way towards gaining the patient's confidence in the treatment, and the manner and deportment of the physiotherapist gives confidence in her ability to direct this treatment with efficiency. The calm and cheerful atmosphere created, once this confidence is established, supplies the background essential for either concentrated effort or maximal voluntary relaxation, and ensures the co-operation of the patient.

The co-operation of the patient is required for the performance of both passive movement and active exercise. During passive movements, except in cases of paralysis or when there is general anaesthesia, this co-operation takes the form of voluntary relaxation on the part of the patient while he permits his joints to be moved for him. It is relatively easy to persuade a patient to submit to any form of passive therapy provided it is pleasant and comfortable, but if pain or discomfort result, as they may, especially during some forced passive movements, a much greater degree of co-operation is required for him to permit the movement. In this case the patient must be convinced of the ultimate benefit of the treatment.

Voluntary effort on the part of the patient and an understanding of what is required of him are essential for the performance of active exercise and he must be stimulated and given every encouragement to make this effort. The design of the exercises and the manner in which they are presented are of the greatest importance in eliciting maximum effort.

THE TREATMENT ROOM

An atmosphere of efficiency is created by order and cleanliness in the treatment room, which should be light and well ventilated. In winter some form of heating is essential to enable the wearing of clothing suitable for exercise, while in summer some additional outdoor space is an advantage for use in fine weather. When artificial lighting is required it should be adequate and well diffused, electric bulbs and shades being protected wherever activities involving the use of balls, beanbags or sticks are to be carried on. A clean floor with a non-slippery surface, such as close-grained unpolished wood or rubberised linoleum, is ideal. Sufficient space should be available to allow each patient to move freely without fear of collision with other patients or apparatus.

All portable apparatus, which will be required for the exercises, must be collected before they are begun so that it is at hand when needed and time is not wasted in fetching it during the period of treatment. Fittings such as wall-bars, horizontal bars and the like must be in good condition and inspection of these at frequent intervals by a competent authority is essential to ensure safety. When not in use, movable apparatus such as plinths, forms, stools and mattresses should be stacked neatly to make the most of the available free space. An adequate supply of small portable apparatus makes it possible for each patient to practise individually, and suitable containers for balls, bands, quoits, ropes, etc., should be provided and placed where both patients and physiotherapists know where to find them and to return them after use. A selection of brightly coloured beanbags, balls and bands are much appreciated by both children and adults, and when in use they give a colourful and cheerful appearance to the room.

Tidiness and an intelligent use of both space and apparatus do much to obtain the maximum value from the available facilities and to relieve apparent overcrowding.

CLOTHING

For the Patient. All garments which restrict movement or make it impossible for the physiotherapist to observe it accurately should be removed. It is not always easy to persuade patients to wear suitable clothing, but if a firm but reasonable stand is taken, from the first treatment, with every patient, the idea is soon accepted.

Generally speaking, it is advisable for men to strip to the waist for upper limb and trunk exercises, while for leg and strenuous trunk exercise the wearing of shorts instead of trousers is essential. Women should remove their dresses or blouses, and a petticoat or vest with adequate knickers, or shorts if available, are suitable for most exercises. Corsets and constricting belts, other than surgical belts which are only removed with the doctor's permission, must be taken off prior to trunk exercises. Constant vigilance on the part of the physiotherapist is necessary to ensure this, as women are even more loath to remove their corsets than the men are to remove their collars and ties! Rubber shoes may be required for activities where the floor is unsuitable for bare feet. A woollen bathing suit is often a suitable garment for small children to wear for treatment except in very cold weather.

For the Physiotherapist. The physiotherapist must be neatly dressed in some suitable uniform which allows her sufficient freedom of movement.

Punctuality

Co-operation between the patient and the physiotherapist is necessary to see that treatments begin and end punctually, thus avoiding much uncertainty and waste of time. This is particularly important in the case of group work for Out-Patients, when exercises must start at a prearranged time whether or not all members of the group are present. Time is valuable to many who get an hour or so off work to come for treatment and those who arrive punctually should never be kept waiting.

Formations

The essential condition in positioning a patient for exercise is that he shall have ample space in which to move freely, and it is usually desirable that he should have a clear view of the physiotherapist who is instructing him. It is of equal importance that the physiotherapist should be able to see the patient from an angle which is suitable for assessing the efficiency of his movements.

Regular formations, such as lines, files and circles, may be used provided valuable time and energy are not wasted in achieving them, but it is often quicker and equally satisfactory to use the less formal method of merely asking the patient to 'find a space' and then checking that he has ample room for movement. Physiotherapists who are unaccustomed to group work often find it easier to observe faulty movement when a regular formation is used, but a less formal arrangement has the advantage of emphasising the individual character of the exercise in which each patient attempts to improve his own performance without any suggestion of regimentation.

Whenever several groups are exercising in the same room at one and the same time it is advisable to arrange that each one faces in a different direction to avoid attention being distracted by the activities of other groups.

The position of the physiotherapist with regard to the group she is instructing is also of importance. When possible she should stand well back from the group, in front of it and slightly to one side, as in this position she can usually see and be seen by all without effort. When space is limited a small platform on which she can stand, placed close to the group, is of great assistance. A position directly in front of a line or in the centre of a circle of patients is to be avoided. When a lateral view of an exercise is required to check the accuracy of the movement, the group can be turned to face in another direction or the physiotherapist can move round to the side.

The Deportment of the Physiotherapist

The posture and movements of the physiotherapist do much to demonstrate her attitude towards both the patients and the treatment. Good posture, alert but well-controlled movements when these are required, and an absence of mannerisms give an impression of interest and efficiency.

It is advisable to sit or stand still when actually giving verbal instructions unless these are accompanied by a demonstration of the exercise. Restless or purposeless movements distract attention from what is being said as, for example, in the case of a speaker who walks to and fro continuously like a caged animal!

Method of Instruction

Many exercises and most activities consist of a series of simple movements. For teaching purposes it is usually advisable to analyse the exercise and allow the patient to practise each of these simple movements before attempting to build them up into the sequence which constitutes the exercise as a whole. Otherwise attention becomes focused on the effort to remember the sequence rather than on the accurate performance of the constituent movements, e.g. transference of weight is perfected before the sequence of movements which constitute walking is attempted.

Instruction may be given verbally, by demonstration, or by the use of passive movement.

Verbal Instruction

Informal Explanation. The patient is told what to do in a few simple words, e.g.

Lift your arms sideways!

Try to *make* a fist!

Bend your leg *up*; *stretch* it *out*!

Economy of words is essential for clarity and a single instruction, which is carried out immediately, leaves the patient in no doubt as to what is required of him. Numerous instructions and lengthy explanations are confusing, as the first of them is generally forgotten by the time the exercise is due to start; likewise the constant repetition of unnecessary phrases such as 'I want you to' and 'Yes, that's right', are better omitted as they contribute little or nothing to the explanation.

Formal Commands. These are now rarely used, but they are a convenient method of starting an exercise which is well known. They specify the point in time at which the exercise is to begin, so that many patients can perform it in unison, or to a definite beat dictated by a musical accompaniment. A formal command is essential to achieve a fair start for most competitive games and activities

Each command consists of three parts, (*i*) Preparatory or Descriptive, (*ii*) Pause, (*iii*) Executive word, e.g.

(i)	(ii)	(iii)
stride jump, with Arm lifting and lowering	....	*begin!*
On your marks	....	*go!*

Instruction by Demonstration

The use which is made of demonstration in the teaching of exercise is largely a matter of individual preference, some considering it an essential factor in presenting any exercise, others preferring to use it only when the occasion demands and as an adjunct to verbal explanation. Any demonstration given by the physiotherapist must be as perfect and as accurate as possible, so that the patient gets the correct mental picture of the exercise. Much valuable time may be wasted while the patient remains inactive watching a prolonged demonstration when he would be more profitably employed in an attempt to 'do' the exercise. It is often preferable for the physiotherapist to do the exercise with the patients in response to her own instructions, except when a rest period will be beneficial to them. It is interesting and very salutary to estimate, with the help of a stop-watch, the proportion of the treatment time during which exercise is actually performed by the patient in relation to that used exclusively by the physiotherapist in talking and demonstrating.

Instruction by Passive Movement

It is rarely necessary to use this method except for patients who are blind or deaf, or for those who have sustained long periods of inactivity during which the pattern of the movement, as recorded by the kinaesthetic sensation, has been forgotten.

Corrections

The need for corrections is inevitable, but they can be reduced to a minimum by clear, accurate instruction, and where possible it is always better to foresee a mistake and prevent it. Verbal corrections should invariably be constructive in character and they may be given while the exercise is in progress or during rest periods between bouts of activity. The patient's reaction to correction must be observed and suitable praise or encouragement given whenever a real effort is made to improve, e.g. *Lift your head higher*, or *That is better!* Unless some comment is made, patients often feel their efforts have passed unnoticed and they always appreciate being told how they are progressing.

For group work corrections may be general or individual.

General Corrections. These are given when several members of the group will benefit from them or to give a nervous or inattentive patient a chance to improve his performance without drawing the attention of the group to his mistake.

Individual Corrections. The patient is addressed by name before a verbal correction of this kind is given, or the physiotherapist can give manual help and guidance by standing beside a shy or nervous patient.

Patients often show a keen interest in observing, correcting and encouraging each other, and this is to be encouraged on suitable occasions, provided their efforts are carefully supervised.

The Voice of the Instructor

The physiotherapist's voice is of major importance in interpreting the nature, speed, rhythm and intensity of the exercises. Diction must be good so that every word can be heard clearly without strain, and a voice which is relatively low-pitched is an advantage as it is easily produced and pleasant to listen to. The volume should always be suited to the room and to the size of the audience and any tendency to shout, especially in group work, must be resisted.

Variation in pitch and volume, in the duration of words and the timing of sentences, makes it possible to interpret the precise nature of an infinite variety of activities and ensure emphasis where it is required. A voice which is flexible and varied commands attention from the listeners, and is never dull.

Every patient who has received instruction in active exercise should feel that he has benefited by, and enjoyed, the treatment. In addition, he should clearly understand that having gained a knowledge and experience of suitable exercises he is expected to co-operate in accelerating his own recovery by practice at home.

APPENDIX

I

DERIVED POSITIONS

THE position of the arms, legs or trunk may be altered in each of the fundamental positions to modify the effect of the positions, or of the exercises which are performed from them subsequently.

The purpose for which the modification is made may be:—

1. To increase or decrease the size and stability of the base.
2. To raise or lower the centre of gravity.
3. To ensure maximum local or general relaxation.
4. To alter the position of the body in relation to gravity.
5. To provide control or fixation for a particular part of the body so that movement may be localised to a specific area.
6. To increase or decrease the muscle work required to maintain the position.
7. To increase or decrease the leverage.
8. To provide a convenient position from which a particular exercise is to be performed.

POSITIONS DERIVED FROM *STANDING*

By Alteration of the Arms

Only the description and static muscle work to hold the position of the arms is given below, that of the fundamental position to which this is added is not repeated (see Fundamental Positions, p. 20).

WING STANDING (wg. st.)

The hands rest on the crests of the ilia, the fingers, which are extended and adducted, being anterior and the thumbs posterior. The wrists are extended, forearms pronated, elbows flexed and shoulders abducted. The elbows point straight sideways.

Muscle Work. The Adductors of the Shoulder Joint and Extensors of the Elbows work slightly to press the hands to the trunk.

Effects and Uses. As the arms are held away from the trunk from the axilla to the iliac crests, the position allows the physiotherapist to grasp the patient round the shoulders during some trunk exercises. The fixed position of the arms prevents their swinging during trunk exercises. As this swing usually amplifies the movement and leaves the thorax free, the position should be avoided unless it serves some definite and useful purpose. It was at one time used extensively just to make the exercise appear tidy !

LOW WING STANDING (low. wg. st.)

This is similar to the previous position, the fingers being placed across the front of the hip joints.

Effects and Uses. This is a position of control as the patient is able to feel with the hands the movement of flexion at the hip joint, tilting and lateral swing or any rotation of the pelvis, which may occur during the performance of an exercise.

UNDER BEND STANDING (und. bd. st.)

The fists are pressed against the lateral wall of the chest, the forearms being pronated and the elbows flexed and the shoulders are abducted and medially rotated. The elbows point straight sideways.

Muscle Work

(*i*) The Flexors and Extensors of the Wrist work reciprocally to stabilise the joint.

(*ii*) The Flexors of the Elbows keep the fists well up towards the axillae.

(*iii*) The Adductors of the Shoulders press the fists to the sides.

Effects and Uses. This too is a position of control which enables the site of the movement to be felt with the hands. It is used to localise movement during lateral flexion of the thoracic spine.

BEND STANDING (bd. st.)

The shoulders are laterally rotated and adducted strongly, the elbows are flexed, the forearms are supinated with wrists and fingers flexed to rest above the lateral border of the acromion process.

Muscle Work

(*i*) The lateral Rotators and Adductors of the Shoulder work strongly.

(*ii*) The Retractors and Depressors of the Scapulae work strongly as fixators.

(*iii*) The Flexors of the Elbows and Supinators of the Forearm work to maintain the position of the forearms.

(*iv*) The Flexors of the Wrists and Fingers may work slightly.

Effects and Uses. The position is corrective for the position of the upper back, and the thorax is expanded. It may therefore be held during some trunk exercises to intensify their effect or used prior to arm stretching exercises. Full flexion of the elbow reduces the leverage for the Abductor Muscles of the Shoulder Joint, making it a suitable position from which to perform abduction movements when these muscles are weak.

REACH STANDING (rch. st.)

The shoulders are flexed and the elbows extended so that the arms are held parallel, shoulder width apart and at right angles to the body.

Muscle Work

(*i*) The Shoulder Flexors maintain the position against gravity.

(*ii*) The Transverse Back Muscles control the forward movement of the scapulae round the chest wall which is associated with shoulder flexion.

(*iii*) The Extensors of the Elbows, Radial Flexors of the Wrist and Extensors of the Fingers work slightly to keep the arms straight.

Effects and Uses. In the upright position the forward raising of the arms brings the centre of gravity of the body forwards and there is a natural tendency to over-compensate for this by extension of the lumbar spine. Control of the position of the scapulae by the Retractors and Depressors is essential to avoid restriction of inspiratory movements. The position is used prior to some arm and trunk exercises in the sagittal plane, and to assist balance during balance walking sideways. The hands may be supported on, or may grasp, some apparatus (*rch. gr. st.*) and this obviates the use of the Shoulder Flexor Muscles when the arms are used to control or steady the body for leg or head exercises.

YARD STANDING (yd. st.)

The arms are straight and elevated sideways to a horizontal position.

Muscle Work

(*i*) The Abductors of the Shoulder work strongly with the Lateral Rotators of the Scapulae to stabilise the arms.

(*ii*) The Extensors of the Elbows, Wrists and Fingers work to hold the limbs in a straight line.

(*iii*) The tendency to elevate the shoulder girdle is controlled by the Scapulae Depressors.

Effects and Uses. The Abductors of the Shoulder work at a marked mechanical disadvantage as the length of the weight arm of the lever so greatly exceeds that of the power arm. The position is corrective for the posture of the upper back, facilitates body balance and is convenient for arm swinging exercises.

One arm only may be used (½ *yd. st.*), and when the hand grasps a support at a suitable height (½ *yd. gr. st.*) the body is steadied for leg and trunk exercises. Palms may be turned forwards (*yd. palms f. st.*) or upwards (*yd. palms u. st.*), the latter involving an additional lateral rotation at the shoulder joint with consequent further bracing of the upper Back Muscles.

ACROSS BEND STANDING (acr. bd. st.)

The upper arm remains as in the yard position but the forearm is fully flexed at the elbows and the palms face downwards.

The position is used prior to scapula retraction and arm-flinging exercises, often to amplify trunk rotation when the arms are used alternately.

HEAD REST STANDING (H. rst. st.)

The upper arm is elevated slightly from the *yard palms upwards* position, the elbows being bent so that the finger-tips touch and rest lightly on the top of the head. The elbows point straight sideways.

Muscle Work

(*i*) The Abductors of the Shoulder and Lateral Rotators of the Scapulae work to maintain elevation of the arm while the Retractors and Depressors of the Scapulae control the position of the upper back.

(*ii*) The Extensors of the Elbows work against gravity to prevent pressure of the hands on the head.

(*iii*) The Flexors of the Wrist keep the hands in line with the forearms.

Effects and Uses. The thorax is expanded and the position of the head is controlled by the touch of the fingers. Elevation of the arms raises the centre of gravity of the body as a whole. The position is used to train and control the poise of the head and upper back or to increase the leverage for trunk exercises.

The fingers may touch a few inches above the head as if to form a frame for the face (*ring st.*).

STRETCH STANDING (str. st).

The arms are fully elevated so that they are in line with the body, parallel to each other and with palms facing.

Muscle Work

(*i*) The Abductors, Extensors and Lateral Rotators of the Shoulder work strongly in conjunction with—

(*ii*) The Lateral Rotators of the Scapulae, to hold the arms in position.

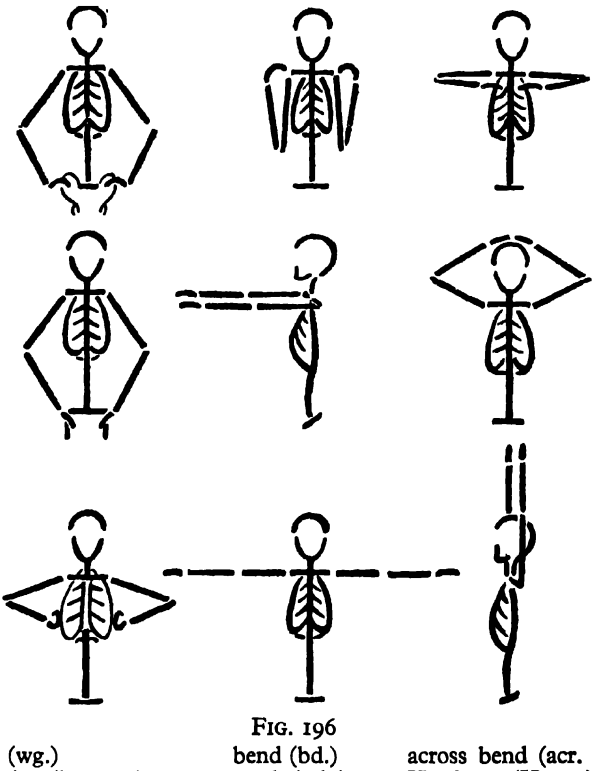


FIG. 196

wing (wg.)	bend (bd.)	across bend (acr. bd.)
low wing (low wg.)	reach (rch.)	Head rest (H. rst.)
under bend (und. bd.)	yard (yd.)	stretch (str.)

(*iii*) The Extensors of the Elbows keep them straight.

(*iv*) The Wrists and Fingers are kept in alignment by interplay between the muscles working over the wrist and by the Extensors of the Fingers.

Effects and Uses. The muscle work is strong, often due to the tension of shortened opposing muscles, particularly Pectoralis Major and Minor and Latissimus Dorsi. Tension of the former expands the thorax and respiration (expiration) is difficult, and in the upright position the arterial circulation to the arms is impeded by gravity. The position is unsuitable for weak patients or those who suffer from respiratory conditions. It is strongly corrective for the position of the upper back and gives a feeling of stretching the spine. Elevation of the arms raises the centre of gravity of the body and affords additional leverage in many trunk exercises. Elevation to the oblique position (*obl. str. st.*) reduces the effect of the position. The hands may grasp some over-head support (*str. gr. st.*) or the fingers may be clasped (*str. clasp st.*). When one arm holds the position a lateral flexion of the thoracic spine to the opposite side maintains the equilibrium of the body (½ *str. st.*). This may be useful in the treatment of scoliosis.

POSITIONS USED TO FIX THE SHOULDER GIRDLE

The arms may be held to the sides while the hands grasp suitable apparatus (*low gr.*), they may be laterally rotated strongly (*A. rot. o.*) or folded across the chest (*A. folded. st.*). These positions are used during head exercises.

By Alteration of the Legs

These positions involve change in the shape or size of the base. Only the description and static muscle work which differs from, or is in addition to, that required for the fundamental position is given.

CLOSE STANDING (cl. st.)

The legs are rotated inwards at the hips so that the medial borders of the feet are adjacent.

Muscle Work. The Leg Muscles work more strongly than in the fundamental position.

Effects and Uses. The size of the base is reduced and balance is more difficult, it is therefore a progression on the *standing* position. Relaxation of the lateral rotators of the hip often results in a loss of the bracing effect on the whole leg including the longitudinal arches of the feet, which accompanies the contraction of these muscles when the foot is fixed.

TOE STANDING (Toe st.)

The heels are pressed together and raised from the floor.

Muscle Work. The Plantaflexors of the Ankle Joint work strongly against gravity to keep the heels elevated. All the Leg Muscles work more strongly than in the fundamental position to keep the balance.

Effects and Uses. The base is reduced and the centre of gravity raised, so this is used as a balance position. Strong work for the Foot Muscles braces the longitudinal arches and there is a tendency for the whole body to stretch, which is of value in the treatment of postural flat feet and posture training generally.

STRIDE STANDING (std. st.)

The legs are abducted so that the heels are two foot-lengths apart. The feet remain at the same angle as in the fundamental position and the weight is equally distributed between them.

Muscle Work. Because the width between the feet is greater than that of the pelvis the Adductors of the Hips may work to prevent the legs from sliding further apart if the position is taken on a slippery floor. On a matt surface, however, or if rubber-soled shoes are worn, friction is sufficient to maintain stability.

Effects and Uses. The effective base is much enlarged laterally, making this an easy and stable position from which to perform exercises, especially those in a frontal plane.

WALK STANDING (wlk. st.)

One leg is placed directly forwards so that the heels are two foot-lengths apart and are on the same line. The body weight is equally distributed between them.

Muscle Work. There is tension on the structures anterior to the hip and on the Calf Muscles of the posterior leg, therefore the Extensors of the Hip and Knee of this leg work strongly to maintain the position.

Effects and Uses. The base is much enlarged in the antero-posterior direction stabilising the body for exercises in a sagittal plane. Rotation of the pelvis towards the side of the forward leg is prevented by the position of the back leg, the position therefore may be used to localise rotation to the spine. Tension on the Hamstrings of the forward leg likewise prevents forward tilting of the pelvis in trunk flexion exercises.

HALF STANDING (½ st.)

The whole weight of the body is supported on one leg, the other may be free or supported in a variety of positions.

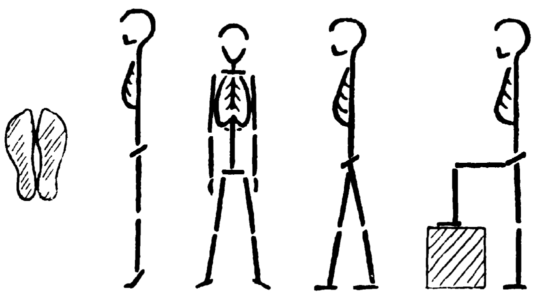


FIG. 197

Position of Feet in close standing | Toe standing (Toe st.) | stride standing (std. st.) | walk standing (wlk. st.) | step standing (step st.)

Muscle Work

(*i*) The Abductors of the Hip of the standing leg work to maintain the centre of gravity over the base by a slight lateral tilting of the pelvis and—

(*ii*) The Lumbar Side Flexors of the opposite side work to bring the trunk into alignment.

(*iii*) All the muscles of the supporting leg work more strongly than in *standing* to support the additional weight and preserve balance.

Effects and Uses. The unsupporting leg is free for movement. Balance is more difficult as the size of the base is reduced.

The leg which is freed from body weight may rest in a variety of positions, e.g. on a stool with hip and knee bent (*step st.*); this relaxes the tension on the abdominal wall on this side and may be used after certain abdominal operations. The foot may be supported with the knee extended on apparatus of a convenient height (*F. sup. f. or o st.*). Support of the foot in a forward direction results in tension on the Hamstrings and straightening of the lumbar spine, and support sideways increases the lateral tilt of the pelvis and the lumbar side flexion. Finally, the toes only may rest lightly on the floor (*Toe sup. st.*); this has the additional effect of bracing the arches of the foot and the leg may be supported in any direction (*f. o. b. or s.*).

By Alteration of the Trunk

LAX STOOP STANDING (lax. stp. st.)

The hips are flexed and the trunk, head and arms are relaxed so that they hang forwards and downwards. Balance is maintained by a slight plantar-flexion at the ankle joints, causing a backward inclination of the leg (Fig. 189).

Muscle Work. Very little muscle work is required except in the region of the ankle joint, where the Dorsiflexors stabilise the position of the joint while the Intrinsic Foot Muscles grip the floor.

Effects and Uses. The amount of forward flexion is dictated by the tension which develops in the Hamstrings and Lumbar Muscles. The position may be used to train local relaxation of the upper body and to assist expiration. It is used prior to extension exercises of hips and spine, particularly those which occur progressively, as in uncurling to the upright position. The position is unsuitable for weak or elderly patients as the dependent position of the body causes an increased blood flow to the head which may be followed by depletion on raising to the upright position and consequent feeling of giddiness. When the knees are allowed to bend in the position (*lax stp. K. bd. st.*), tension on the Hamstrings and lumbar muscles is reduced, giving a feeling of relaxation right through the body.

STOOP STANDING (stp. st.)

The hip joints are flexed while the trunk, head and arms remain in alignment and are inclined forwards. The backward inclination of the legs is greater than in the previous position. The angle to which the trunk is inclined is usually about a right angle but depends on the tension of the Hamstrings which control the forward tilt of the pelvis when the knees are straight (Fig. 198).

Muscle Work

(*i*) The Muscles of the Feet work as in the previous position.

(*ii*) The Extensors of the Knees may work to counteract the tension of the Hamstrings.

(*iii*) The longitudinal and transverse Back Muscles and the Extensors of the Shoulders and Elbows maintain the position against the pull of gravity.

(*iv*) The posterior Neck Muscles, controlled by the Pre-vertebral Muscles, support the head.

Effects and Uses. The strong work for the Neck and Back Muscles with stretching of the spine, which occurs in the horizontal position, trains good posture of the upper back. Fixation in flexion of the lumbar spine localises movement to the joints above this level. It is a valuable but difficult position to hold correctly.

By Alteration of the Legs and Trunk

FALLOUT STANDING (fallout st.)

One leg is placed directly forwards to a distance of three foot-lengths and this knee is bent; the back leg remains straight and the body is inclined forwards in line with it.

Muscle Work

(*i*) The Extensors and the Foot Muscles of the forward leg work strongly to support most of weight, while the Extensors of the Back Leg

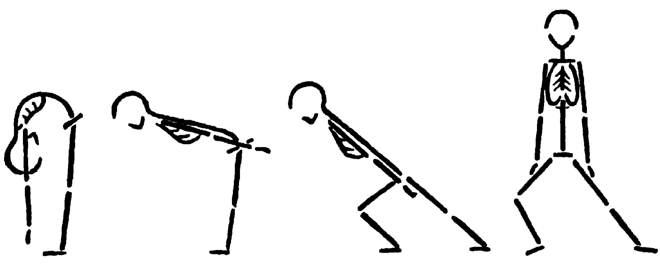


FIG. 198

lax stoop standing (lax stp. st.) | stoop standing (stp. st.) | fallout standing (fallout st.) | lunge sideways standing (lunge s. st.)

keep the trunk and leg straight. The Dorsiflexors of this foot work to keep the heel on the ground.

(*ii*) The Head and Trunk Muscles work as in *stoop standing*, but as there is a degree of rotation and lateral tilt of the pelvis away from the forward leg, balance is maintained by the action of the Trunk Rotators and the Lumbar Muscles on this side.

Effects and Uses. The muscle power and co-ordination required to hold the position is considerable, and it may be used in the treatment of spinal curvature.

When support is given to the arms or shoulders, it is an excellent position in which to utilise the body weight, either for giving pressure or resistance in the direction of the fallout.

The forward leg may be placed outwards (*fallout o. st.*) or sideways (*fallout s. st.*), or the toes of the straight leg may be stretched so that they only rest lightly on the floor (*toe fallout st.*).

Lunge positions are similar with regard to the placing of the legs, but the body always remains in a vertical position.

POSITIONS DERIVED FROM *KNEELING*

As in the case of the *standing* position, only the description and static muscle work to hold the position is given, that of the fundamental position is not repeated.

The positions of the arms are the same as in *standing* and may be added to the *kneeling* position as required.

HALF KNEELING (½ kn.)

One knee supports most of the body weight and the other leg is bent to a right angle at hip, knee and ankle so that the foot is supported on the ground in a forward direction (Fig. 199).

Muscle Work

(*i*) The Abductors of the Hip Joint of the supporting leg, and the Lumbar Side Flexors of the opposite side, work to balance the trunk (as in ½ *st.*).

(*ii*) The Extensors of the Hip and Knee of the forward leg work slightly to assist balance.

Effects and Uses. This position is similar to *step standing* (see ½ *st.*) and may be modified by stretching the forward leg in a sideways direction (*L. str.* ½ *kn.*). The pelvis is well fixed in the position for trunk side bending and rotation exercises when the trunk moves in a direction away from the supporting leg.

KNEEL SITTING (kn. sitt.)

The knees and hips are flexed so that the patient sits on his heels (Fig. 199). The position is sometimes used for small children, but most people find it very uncomfortable.

PRONE KNEELING (pr. kn.)

The trunk is horizontal, supported under the shoulders by the arms, and at the pelvis by the thighs, which must be held vertical. The head is held in line with the trunk (Fig. 199).

Muscle Work

(*i*) The muscles round the Shoulder and Hip Joints work to stabilise the supporting limbs at right angles to the trunk.

(*ii*) The Flexors of the Lumbar Spine prevent hollowing of the back.

(*iii*) The Extensors of the Neck and Head, controlled by the Prevertebral Neck Muscles, keep the head in alignment.

Effects and Uses. The position is stable and comfortable and suitable for many trunk and head exercises as the spine is relieved of the weight of the head and shoulders and therefore it tends to straighten and elongate. The pelvis is free for antero-posterior and lateral movement, but fixed for rotation. The body may be inclined forwards and downwards by abducting

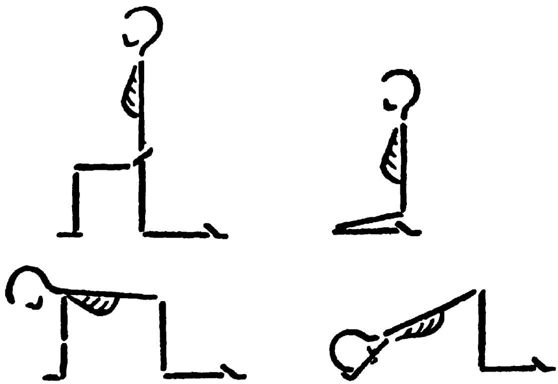


FIG. 199

half kneeling ($\frac{1}{2}$ kn.) — kneel sitting (kn. sitt.)

prone kneeling (pr. kn.) — inclined prone kneeling (incl. pr. kn.)

the shoulders and bending the elbows (*incl. pr. kn.*), this expands the thorax and localises lateral flexion to the thoracic region as during Klapp's Crawling Exercises. Alternatively, the forearms may rest on the floor with the hands together and the head resting on them; in this way a weakened pelvic floor can be relieved of the weight of the viscera or the uterus may be assisted by gravity into the normal position.

POSITIONS DERIVED FROM *SITTING*

As in the case of the kneeling position, only the description and muscle work which differs from that of the fundamental position is given. The positions of the arms are the same as in standing.

Positions of the Legs

STRIDE SITTING (std. sitt.)

This is exactly similar to the fundamental position, except that the legs are abducted so that the feet are up to two foot-lengths apart. This increases the stability of the position, especially if the feet are pressed to the floor.

RIDE SITTING (ride sitt.)

The patient sits astride suitable apparatus, such as a gymnastic form, which may be gripped between the knees by the Adductor Muscles of the Hips, making it a very steady position for head, arm and trunk exercises.

When the position is taken on a high plinth (*high ride sitt.*), the thighs may be strapped to the plinth to afford additional fixation, in which case no muscle work is required in the legs.

CROOK SITTING (crk. sitt.)

When sitting on the floor, the knees are bent so that the feet are together and flat on the floor. The knees may be together or apart.

Muscle Work

(*i*) The Flexors of the Hip work strongly to prevent excessive flexion of the lumbar region and to support the thighs. The Flexors of the Knees

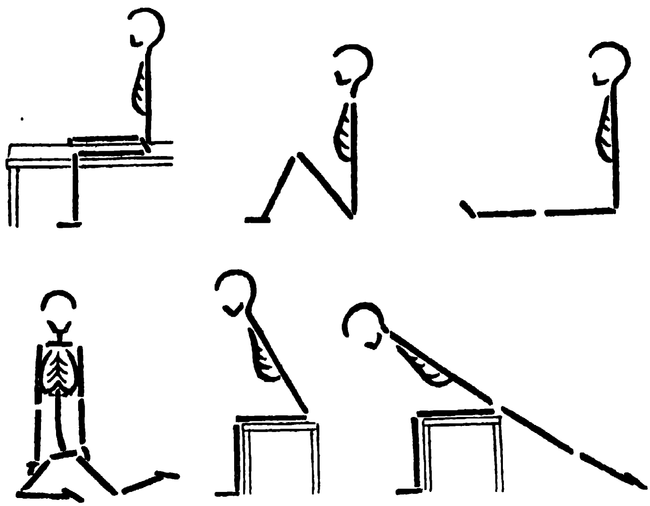


FIG. 200

ride sitting (ride sitt.)	crook sitting (crk. sitt.)	long sitting (lg. sitt.)
side sitting (s. sitt.)	stoop sitting (stp. sitt.)	fallout sitting (fallout sitt.)

and Plantarflexors of the Ankles may also work to afford additional fixation of the legs.

(*ii*) The longitudinal and transverse Back Muscles work strongly to maintain the upright position of the trunk.

Effects and Uses. The pelvis is fixed with a decreased tilt and the lumbar region is flexed so that movement can be localised to the upper trunk, as in the treatment of kypho-lordosis. Strong work for the Extensors of the Thoracic Spine to hold the position is of value in training their efficiency.

LONG SITTING (lg. sitt.)

This is similar to the previous position, but the knees are extended so that the whole leg is supported. The Extensors of the Knees work to counteract the increased tension of the Hamstring Muscles. When the legs are apart (*std. lg. sitt.*) this tension is somewhat reduced, but the position is difficult and unsuitable for most adults.

CROSS SITTING (X sitt.)

This is also similar to *crook sitting*, but the ankles are crossed and the hips strongly abducted and laterally rotated, so that the lateral aspect of the knees is pressed to the floor. Tension on the Hamstrings is reduced but the Adductors of the Hip are stretched. For this reason the position is uncomfortable for most adults, but suitable for children during head, arm and trunk exercises as the pelvis is fixed and stable.

SIDE SITTING (s. sitt.)

For left side sitting the left leg remains as in cross sitting and this hip supports the main weight of the trunk, while the right leg is abducted and medially rotated so that the lower leg is bent and to the side. The pelvis is tilted laterally to the left, and the Lumbar Side Flexors on the right side work to keep the trunk upright. The position is used to increase lateral mobility of the lumbar spine or for fixation in the *side bend* position when treating scoliosis (Fig. 200).

HIGH SITTING (high sitt.)

The fundamental sitting position is taken on a high plinth or table but the feet remain unsupported. This is convenient for some foot and knee exercises.

Positions of the Trunk

STOOP SITTING (stp. sitt.)

This is similar to but easier and more stable than *stoop standing* position, and is therefore very useful for arm and upper back exercises when hollowing of the lumbar region is to be avoided (Fig. 200).

The arms may be folded and supported on a table (*A. lean sitt.*) allowing the Back Muscles to relax. This arrangement is convenient for giving back massage when *prone lying* is impracticable.

FALLOUT SITTING (fallout sitt.)

The position is the same as *fallout standing* except that the hip and thigh of the forward leg are supported across a stool, balance is therefore easier and the patient is able to concentrate on movements which may be added (Fig. 200).

POSITIONS DERIVED FROM *LYING*

As in previous cases, only the description and muscle work which differs from the fundamental position is given.

Positions of the Arms

Those which are used are the same as in the standing position, the muscle work, however, is modified and usually reduced by the horizontal position of the body.

Positions of the Legs

CROOK LYING (crk. ly.)

From *lying*, the hips and knees are bent so that the feet rest on the floor or plinth. Provided the feet are fixed by friction, very little muscle work is required apart from that of the Adductors and Medial Rotators of the Hips to prevent the knees from falling apart.

Effects and Uses. Tension is removed from the structures anterior to the hip joint so that the pelvis rolls backwards and the lumbar spine is relaxed on to the supporting surface. As the whole trunk is relaxed and supported horizontally and fixed by its own weight it is an easy position and extensively used to train relaxation and posture.

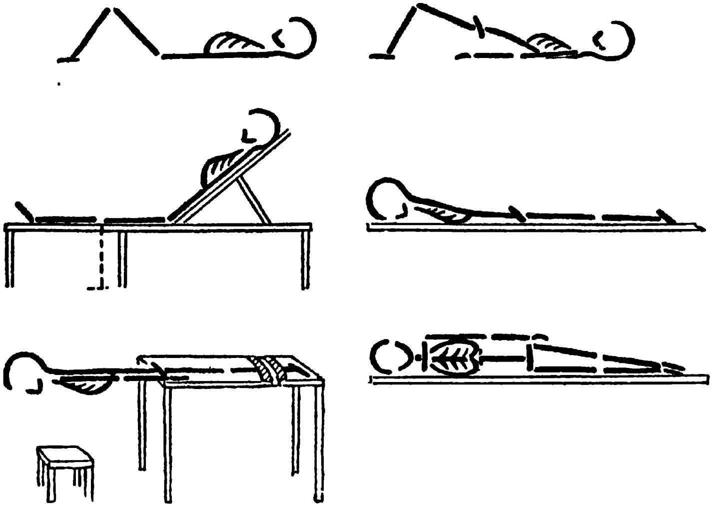


FIG. 201

crook lying (crk. ly.)
crook lying with Pelvis lifted (crk. ly. w. P. lift.)
half lying (½ ly.)
prone lying (pr. ly.)
Leg prone lying (L. pr. ly.)
side lying (s. ly.)

CROOK LYING WITH PELVIS LIFTED (crk. ly. w. P. lift.)

From the previous position the pelvis is elevated so that the trunk rests on the shoulders and is brought into line with the thighs. A firm pillow may be used to support the buttocks, or the Extensors of the Hips may work to hold the position.

Effects and Uses. Pressure of the viscera on the pelvic floor is relieved by gravity as the weight of viscera is directed backwards and upwards towards the Diaphragm; because of this, breathing may be hampered slightly. The position is useful during re-education of the Muscles of the Pelvic floor, in such cases as visceroptosis or after childbirth.

HALF LYING (½ ly.)

The trunk is supported in the oblique position by inclination of the long end of the plinth, or by the arrangement of pillows, while the legs are supported horizontally. It is important to see that the trunk is in an alignment to avoid slumping and so impeding respiration (Fig. 201).

Effects and Uses. The body is relaxed and comfortable in this position and it is suitable for weak and elderly people because breathing is easier than in *lying*, the thorax being less fixed by the weight of the trunk. Movement of all parts of the body can be performed from *half lying*, and it is much used for ward exercises and in the treatment of many chest conditions.

The knees may be bent to increase relaxation of the abdominal wall (*crk. ½ ly.*), or the lower leg may hang over the end of the plinth with the feet resting on the floor.

PRONE LYING (pr. ly.)

Lying face downwards, the body is fully supported anteriorly on the plinth or floor. The position may be active or relaxed.

The Active Position. When this is used as a static holding for posture training or prior to exercise, the head is slightly raised from the supporting surface and the shoulders are drawn down and backwards, the heels being held together and the toes stretched (Fig. 201).

Muscle Work

(*i*) The Pre- and Post-vertebral Neck Muscles work to maintain the position of the head.

(*ii*) The Retractors and Depressors of the Scapulae work to brace the upper back.

(*iii*) The Lateral Rotators of the Hips keep the heels together.

The Relaxed Position. No muscle work is required for the relaxed position (*lax pr. ly.*). In this case the head is usually turned to one side and rested on the hands for comfort and ease in breathing, while the heels roll apart. Tension may be still further reduced by placing a pillow under the abdomen and another under the lower leg, so that the hip and knee joints are slightly flexed and the feet rest free from pressure.

Effects and Uses. Breathing is somewhat restricted by the pressure of the weight of the body on the chest and abdomen, making the position unsuitable for those with heart or respiratory disease.

The active position gives a feeling of the correct alignment of the body which is required in upright positions and as the spine is relieved of weight it tends to elongate and straighten.

The relaxed version of the position is only comfortable for some people, usually the young and the slim.

LEG PRONE LYING (L. pr. ly.)

This is taken on a high plinth, the legs being supported from the anterior superior spines to the feet and stabilised by a strap. The body is held in line with the legs and is unsupported over the end of the plinth. A stool is in position under the trunk to afford support by the arms in the resting position (Fig. 201).

Muscle Work

(*i*) The Pre-vertebral and posterior Neck Muscles, the Extensors of the Hips, and the longitudinal and transverse Back Muscles work strongly to maintain the position of the trunk against gravity.

(*ii*) The Extensors of the Shoulders and Elbows hold the arms to the sides.

(*iii*) The Flexors of the Lumbar Spine control the lumbar region which tends to become hollowed.

Effects and Uses. The muscle work is strong and corrective for the position of the trunk, and strong arm, head and back exercises can be added to increase this effect.

For group exercises, the thighs only may be supported across a form, the feet being fixed between wall-bars or by living support. Care must be taken in this case to see that the fixation of the feet is firm and that it is maintained until the body is supported on the arms for the resting position.

SIDE LYING (s. ly.)

Details of this position vary considerably according to the purpose for which it is to be used.

(*i*) The patient rolls on to the side from *lying* or *prone lying*, using the under arm to support the head. It is an unsteady position used sometimes for strong trunk side bending exercises (Fig. 201).

(*ii*) Alternatively the shoulders may be stabilised by support from the upper arm resting on the ground or plinth in front, the legs being free for movement. When the under hip and knee are fully flexed the pelvis is relatively well-fixed, so that movements of flexion and extension can be localised to the hip joint of the uppermost leg. This is useful especially in sling exercises. Conversely, if the pelvis is stabilised by resting the uppermost knee on the plinth, shoulder exercises for this side of the body can be performed.

(*iii*) An ideal position for relaxation for many people is provided by adapting (*ii*). Three pillows are required, one for the head, one for the uppermost arm to support it and free the chest and so assist respiration, and a third to support the uppermost leg which is bent (Fig. 48).

POSITIONS DERIVED FROM *HANGING*

FALL HANGING (fall hg.)

The body is supported in the oblique position by the arms which grasp a horizontal bar, and by the feet which rest on the floor. The arms are vertical so that the shoulders fall directly below the hands, while the rest of the body is inclined and straight (Fig. 202).

Muscle Work

(*i*) The Flexors of the Fingers grasp the bar and the Wrist, Elbow and Shoulder Muscles work to reduce tension on these joints.

(*ii*) The Retractors of the Scapulae work strongly to draw the trunk upwards between the arms.

(*iii*) The Flexors of the Atlanto-occipital Joint and of the Cervical Spine prevent the head from falling backwards.

(*iv*) The longitudinal and transverse Back Muscles support the trunk.

(*v*) The Extensors of the Hips keep the trunk in alignment and the Plantarflexors press the feet to the floor.

Effects and Uses. The position requires very strong muscle work for the Back Muscles, especially the Scapulae Retractors, which work against gravity and the weight of the body.

OTHER POSITIONS, IN WHICH SOME OF THE WEIGHT IS TAKEN ON THE ARMS

CROUCH SITTING (crch. sitt.)

The hips and knees are fully bent while the trunk is straight and inclined forwards to allow the hands to rest on the floor. The weight is supported mainly on the toes, the heels being together and the knees pressed apart. Balance is maintained by the arms which are shoulder width apart and vertical.

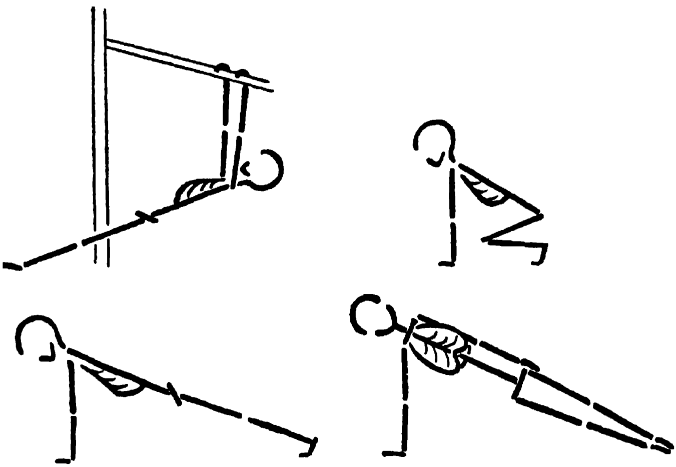


FIG. 202

fall hanging (fall hg.)
crouch sitting (crch. sitt.)
prone falling (pr. fall.)
side falling (s. fall.)

Muscle Work

(*i*) The Intrinsic Muscles of the Feet grip the floor.

(*ii*) The longitudinal and transverse Back Muscles keep the back straight.

(*iii*) The Pre-vertebral and Posterior Neck Muscles support the head.

If additional weight is taken on the hands the Serratus Anterior Muscles work strongly to keep the scapulae against the chest wall, and the muscles round the shoulder joint and the Extensors of the Elbows brace the arms.

Effects and Uses. This is a useful starting position for strong leg extension exercises, as it is steady and the muscles concerned are stretched between their points of attachment. It is much used in training correct landing from high jumping.

Children find it easy and comfortable and readily learn to take weight on their arms, as in the various forms of *crouch* or *'Bunny' jump*.

PRONE FALLING (pr. fall.)

The legs are extended in line with the trunk from the *crouch position* so that the body is supported on the arms, which are vertical, and on the toes.

Muscle Work

(*i*) The Extensors of the Elbows and all the muscles of the shoulder region work strongly to support the weight of the body, while Serratus Anterior holds the scapulae firmly against the chest wall.

(*ii*) The Neck Extensors, controlled by the Pre-vertebral Muscles, maintain the position of the head against the pull of gravity.

(*iii*) The Flexors of the Lumbar Spine prevent sagging of the trunk.

(*iv*) The Extensors of the Knees keep them straight.

(*v*) When the foot is fixed in dorsiflexion the long Flexors of the Toes work with excellent leverage to grip the floor.

Effects and Uses. Many muscles work strongly and the necessary co-ordination is difficult, the position is therefore only suitable for those whose arms are strong in relation to their body length and weight. The body may be taken through a quarter turn so that the weight is supported on the lateral border of one foot, and on one hand (*s. fall.*) In this case the muscles on the under side of the body work strongly and balance is difficult.

II

TERMINOLOGY

The Chartered Society of Physiotherapy has adopted, with some additions, the technical terms, abbreviations and method of description standardised by the Ling Physical Education Association. The correct use and sequence of these abbreviations makes for speed and accurate description of positions or exercises when writing tables.

Abbreviations of Technical Terms

1. *Parts of the Body*

These are denoted by a capital letter, indicating the plural, i.e. A = both arms. For a single or one the figure 1 is used, i.e. 1A = one arm.

Head	H.	Pelvis	P.	Fingers	Fing.
Forehead	Frh.	Shoulder Blades	Sh. bl.	Legs	L.
Neck	N.	Shoulders	Sh.	Knees	K.
Back	B.	Arms	A.	Heels	Hl.
Trunk	T.	Elbows	Elb.	Feet	F.
Side	S.	Wrists	Wr.	Ankles	Ank.
Abdomen	Abd.	Hands	Hnd.		

For parts not included in this list the whole word is written.

2. *Words denoting Position of Arms, Legs or Trunk*

standing	st.	kneeling	kn.	sitting	sitt.
lying	ly.	hanging	hg.	position	pos.
wing	wg.	bend	bd.	reach	rhc.
yard	yd.	rest	rst.	stretch	str.
grasp	gr.	close	cl.	stride	std.
walk	wlk.	relaxed	lax.	stoop	stp.
prone	pr.	crook	crk.	long	lg.
cross	X.	crouch	crch.		

When one limb only is involved, ½ is inserted before the name of the position, i.e. ½ yd = one arm sideways.

3. *Words denoting Movement*

For those ending in -ing, this suffix is omitted. e.g. bend = bending, and stretch = stretching. (Note that these differ from the abbreviations indicating *position*, where bend is bd. and stretch, str.)

Anatomical terms are shortened thus—

flexion	flex.	pronation	pron.	rotation	rot.
abduction	abd.	extension	ext.	eversion	ev.
circumduction	ʘ	adduction	add.	supination	supin.
inversion	inv.				

4. *Words indicating Direction*

right	r.	horizontal	hor.	outwards	o.
forward	f.	inclined	incl.	towards	tow.
upward	u.	between	betw.	lateral	lat.
sideways	s.	left	l.	oblique	obl.
across	acr.	backward	b.	under	und.
medial	med.	downward	d.	behind	beh.

5. *Other Terms*

movement	movt.	jump	j.	wide	wd.
parallel	||	spring	spr.	followed	foll.
support	sup.	assisted	ass.	reverse	rev.
together	tog.	passive	pass.	continuously	cont.
with	w.	stationary	stat.	rebound	reb.
alternate	alt.	opposite	opp.	repeat	rep.
rhythmically	rhythm.	with living support	(.)	balance	bal.
pendulum	pend.			resisted	res.

METHOD OF DESCRIPTION

1. *The Order of Description*

a. When describing an exercise the starting position is put first and the movement follows.

e.g. *yd. std. st.*; A. bend. and stretch.

b. When more than one part of the body participates in an exercise they are included in the following order:—Head, Arms, Trunk, Legs.

e.g. ½ *yd. gr. st.*; 1A. swing. f. u. w. B. arch. and 1L. lift. b.

c. The part of the body to be moved precedes the description of the type of movement and the direction.

e.g. *std. sitt*; T. bend. s.

2. *Punctuation*

a. A semicolon concludes the description of the starting position. In addition, it is a good idea to underline the starting position to ensure that it is not omitted.

e.g. ½ *ly;* alt. Hip and K. flex. and ext.

b. A full stop is put after every abbreviation.

e.g. *crk. sitt.*

c. A comma separates the parts of a series of movements.

e.g. *st.*; 1L. swing. f. and b., K. bend. and stretch., std. j.

d. Brackets enclose figures indicating beat or count, apparatus used, or additional information.

e.g. *ride sitt.* (form); T. rot. (1–4) (slowly), (5–8) (quickly).

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